LABORATORY EXERCISES

IN

HIGH SCHOOL BIOLOGY

DEPARTMENT OF EDUCATION

EDMONTON, ALBERTA

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INTRODUCTION

Laboratory and field work form an essential part of a biology course. Important objectives of the course include (1) an appreciation of laboratory methods; (2) skill in the use of scientific apparatus, especially the microscope; (3) ability to make accurate observations from living specimens and good dissections; and (4) ability to record accurately and concisely the observations made.

Limitations of time and facilities will necessitate doing many experiments as group projects. Care should be taken that every student participates in such projects and makes and records his own individual observations. You learn by doing. You must participate in the experience yourself.

Plants and invertebrate animals are not readily observed in Alberta during the winter season. It is therefore necessary to make some observations of these in their native habitats during the first few weeks of the fall term, and some again in the spring. Some outlines are included in the beginning of this book to direct you in these observations and provide a place for recording them. These will vary, of course, from one locality to another.

Collecting Material

Some material should be collected in the fall, individually or as class projects, and mounted or preserved for use at appropriate times during the year. Among such materials should be the following:

(1) Various types of leaves or whole plants (See Exercises L 13 - L 16).

(2) Flowers such as lily, snapdragon, sweet pea, oat, preserved in formaldehyde.

(3) Fruits such as bean and pea pods, wheat, corn, dried or preserved in formaldehyde.

(4) Liverworts, mosses, ferns, lichens, dried or preserved in formaldehyde.

(5) Insects of as many orders as possible.

(6) Insect eggs and cocoons.

(5) Frog eggs, tadpoles, or adults to be kept in the aquarium or preserved.

(8) Pond water containing small plant and animal life. This can be kept under favorable conditions for several weeks.

An incubator will be very useful in experiments in connection with bacteria, digestion and germination. A suitable one can easily be made from insulation board and heated by an electric light bulb coated with dark paint.

Other equipment and supplies are best obtained from a reliable scientific supply house. A list of these is given in the Appendix.

Making Drawings

Each science has a vocabulary of its own, and characteristic ways of recording information in concise and exact form. In chemistry, formulas, symbols and equations are used for this purpose. In biology, drawings are used extensively. These help the learning process in several ways: (1) The student has to observe carefully before he can make the drawing; (2) The act of drawing impresses the observation upon the mind; (3) The drawing enables the instructor to find out whether the student has observed and understood the subject. Copied drawings are a waste of time.

Here are some points to keep in mind when making drawings:

(1) Be sure you understand the subject before starting the drawing.

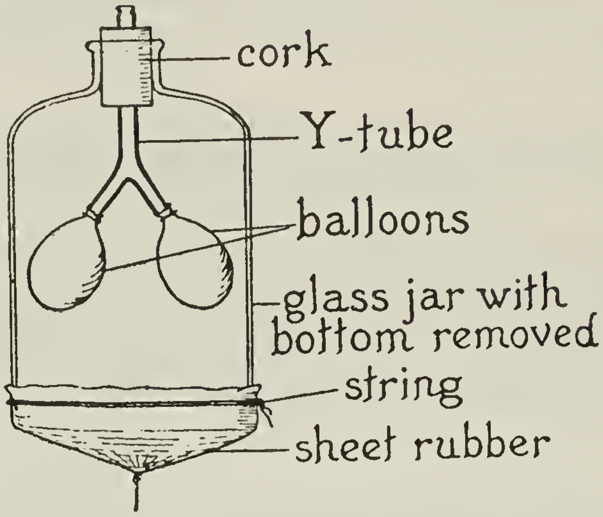
(2) Plan your layout before starting the drawing. Make drawings large.

(3) Use a medium hard pencil. Never try to make an original drawing in ink. Lightly sketch in lines first, erasing when necessary, then make all lines sharp and clear. Hazy lines indicate hazy understanding.

(4) Draw lines with a ruler from each part to the space for its label. Do not have any of these lines crossing other label lines. Label drawings fully and neatly. Use a simple style of printing. In so far as possible, put the labels where they can be read easily without turning the drawing.

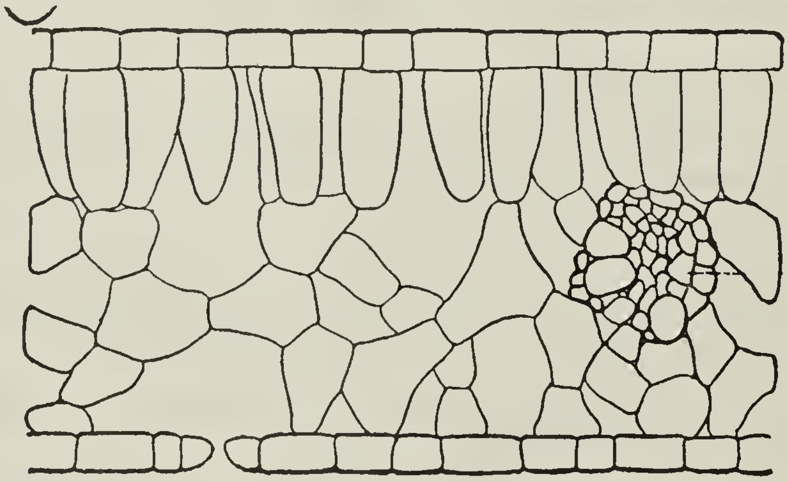
In this Workbook we will use these three types of picture representation:

(1) **Diagrams,** which represent an idea rather than an object. These show how apparatus is set up, or the steps in a process.



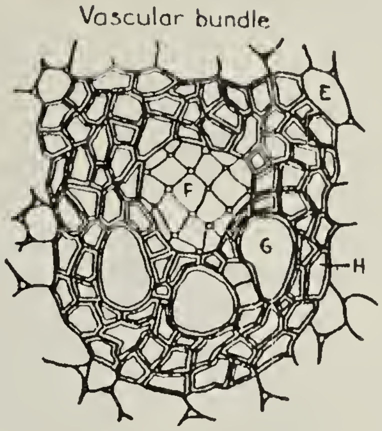
A Diagram

(2) **Sketches,** used to show in outline parts of a typical object under discussion. All details are omitted except the structure under discussion.

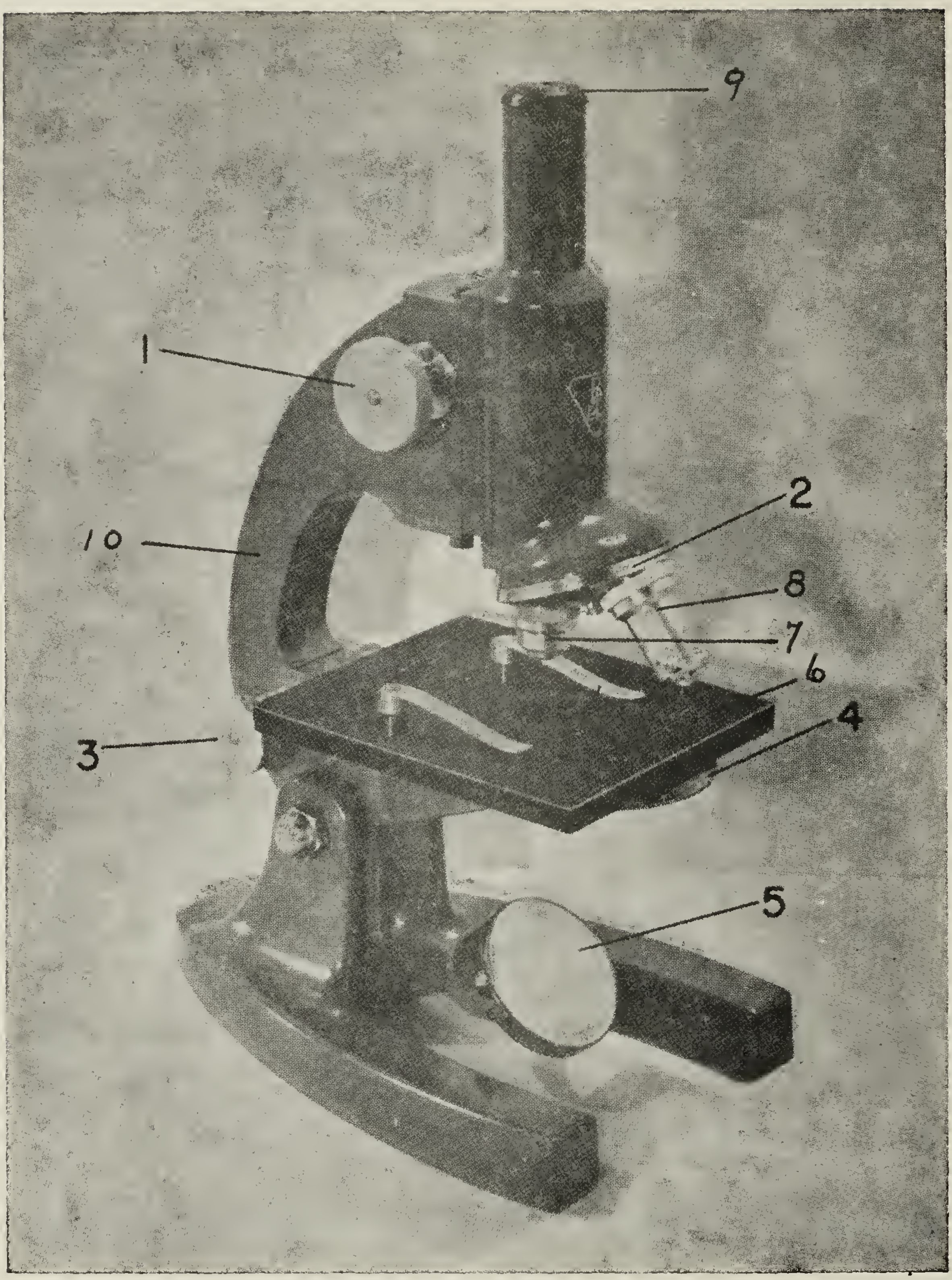


A Sketch

(3) **Representative drawings,** which show in outline the exact shapes and relative positions of structures in the specimen under observation. Shading is seldom necessary or desirable.



A Representative Drawing



The Bausch & Lomb Student Microscope

1—Coarse Adjustment Focusing Knob
2—Revolving Nosepiece
3—Fine Adjustment Focusing Knob
4—Substage Diaphragm Disc
5—Concave Mirror
6—Stage
7—Objective, low power
8—Objective, high power
9—Eyepiece
10—Arm

INSTRUCTIONS FOR THE USE OF THE MICROSCOPE

Learn the parts of the miscroscope shown in the accompanying picture and identify these parts on your instrument before attempting to use the microscope. The microscope is a delicate and expensive instrument. You should not be permitted to use it until you understand the correct procedure.

(1) Always pick up the instrument by the ARM.

(2) Place the instrument on a flat table or desk where there is little or no vibration and where light, natural or artificial, can reach the mirror. Light from the north sky is best. NEVER place it in direct sunlight.

(3) See that the mirror and all lenses are clean. If necessary, clean them with lens paper, or soft paper tissue.

(4) Adjust the mirror so that a beam of light is reflected through the hole in the stage.

(5) Place the slide on the stage so that the object you wish to examine is centered over the hole and adjust the spring clips to hold it there. If you are using a temporary slide the object must be mounted in water beween the slide and the cover slip.

(6) See that the low power objective is in place, then, while watching from the side, using the COARSE ADJUSTMENT KNOB lower the objective to within about one centimeter of the cover slip.

(7) Look through the eyepiece and staring with the iris small adjust it until the dark edges just disappear, giving a clear round spot of light.

(8) Using the COARSE ADJUSTMENT, slowly raise the objective until the object comes in view. If you raise it too far, watch from the side and lower it to within one centimeter of the cover slip, then watch through the eyepiece and raise the objective again. NEVER lower the objective with the coarse adjustment while looking through the eyepiece.

(9) When you have the object in view turn the FINE ADJUSTMENT KNOB either way, until you get the clearest view possible.

(10) If higher magnification is desired, move the slide on the stage until the part of the specimen that you want to see is in the center of the spot of light, then, without touching either knob, revolve the nosepiece until the HIGH POWER OBJECTIVE is in place. When you look through the eyepiece now the object should be in view. Adjust with the FINE ADJUSTMENT KNOB to get the clearest possible view. NEVER USE THE COARSE ADJUSTMENT WHEN THE HIGH POWER OBJECTIVE IS IN PLACE. If you lose the object, revolve the nosepiece to put the low power objective in place and center what you want to see in the field, then replace the high power again.

(11) When you have finished your observation, revolve the nosepiece until the low power objective is in place, remove the slide from the stage, see that the stage and the objectives are clean and dry, then return the instrument to its proper place.

L 1. INSECT PESTS

Observe insect pests that are prevalent in your locality and record your observations in the form provided. Use sketches wherever possible. Include such insects as house fly, mosquito, grasshopper, stinkbug, cutworm, armyworm, wireworm, Colorado potato beetle, blister beetle, wheat stem sawfly.

There are more than twenty orders of insects. The seven commonest orders can be distinguished from one another by the use of this key:

KEY TO SOME ORDERS OF INSECTS

I. One pair of wings only	DIPTERA
II. Two pairs of wings	
A. Forewings hard and shell-like	COLEOPTERA
B. Front part of forewings hard, membranous at end	HEMIPTERA
C. Wings much alike	
(1) Both pairs of wings covered with colored powdery scales	LEPIDOPTERA
(2) Wings thin and transparent	
(a) Forewings heavy, meeting in a ridge over abdomen; hind wings fold fanlike	ORTHOPTERA
(b) Wings held at right angles to the body	
(i) Wings fairly heavy, with prominent veins. Eyes large. Mouthparts for chewing	ODONATA
(ii) Wings with few veins. Often with stings. Usually with a proboscis-like tongue as well as jaws	HYMENOPTERA

INSECT PESTS

NAME AND ORDER	HARM DONE	LIFE CYCLE	CONTROL

INSECT PESTS

NAME AND ORDER	HARM DONE	LIFE CYCLE	CONTROL

L 2. NATIVE BIRDS

Observe birds present in your locality and record your observations here.

NAME	HOW TO IDENTIFY	BENEFICIAL OR HARMFUL HABITS

L 3. WEEDS

Observe weeds that are a serious nuisance in your locality and record your observations here.

NAME	SKETCH LEAF, FLOWER, FRUIT	CONTROL

NAME	SKETCH LEAF, FLOWER, FRUIT	CONTROL

L 4. NATIVE TREES

Observe native trees in your locality and learn to recognize them. Record your observations here. Use sketches.
(Reference: *Native Trees of Canada*)

NAME	TWIG WITH BUDS	LEAF SHAPE	FLOWER OR CONE, AND SEED

NAME	TWIG WITH BUDS	LEAF SHAPE	FLOWER OR CONE, AND SEED

L 5. FUNGOUS DISEASES

Observe symptoms of diseases caused by fungi in your locality and record your observations here.

NAME OF DISEASE	SYMPTOMS	PREVENTION OR TREATMENT

L 6. POND LIFE

Observe the living things in and around the nearest pond. Note adaptations that fit the plants and animals present for life in this habitat. Secure a bottle of water from near the surface, including some scum, and another from the bottom including some mud. Examine these samples under the microscope and sketch the organisms seen. Learn the names of as many as possible.

L 7. NITROGEN CYCLE

Carefully dig up a legume plant and free the soil from the roots. Observe the white nodules on the roots. Draw the roots with the nodules.

What causes these nodules?

How does this illustrate SYMBIOSIS?

Explain the part played by each of the following in the nitrogen cycle:

(a) Nitrogen-fixing bacteria.

(b) Denitrifying bacteria.

(c) Decay producing bacteria.

(d) Nitrite bacteria.

(e) Nitrate bacteria.

L 8. SOIL EROSION

Observe one or more instances of soil erosion in your locality. Describe or map the location.

Is this sheet or gully erosion?

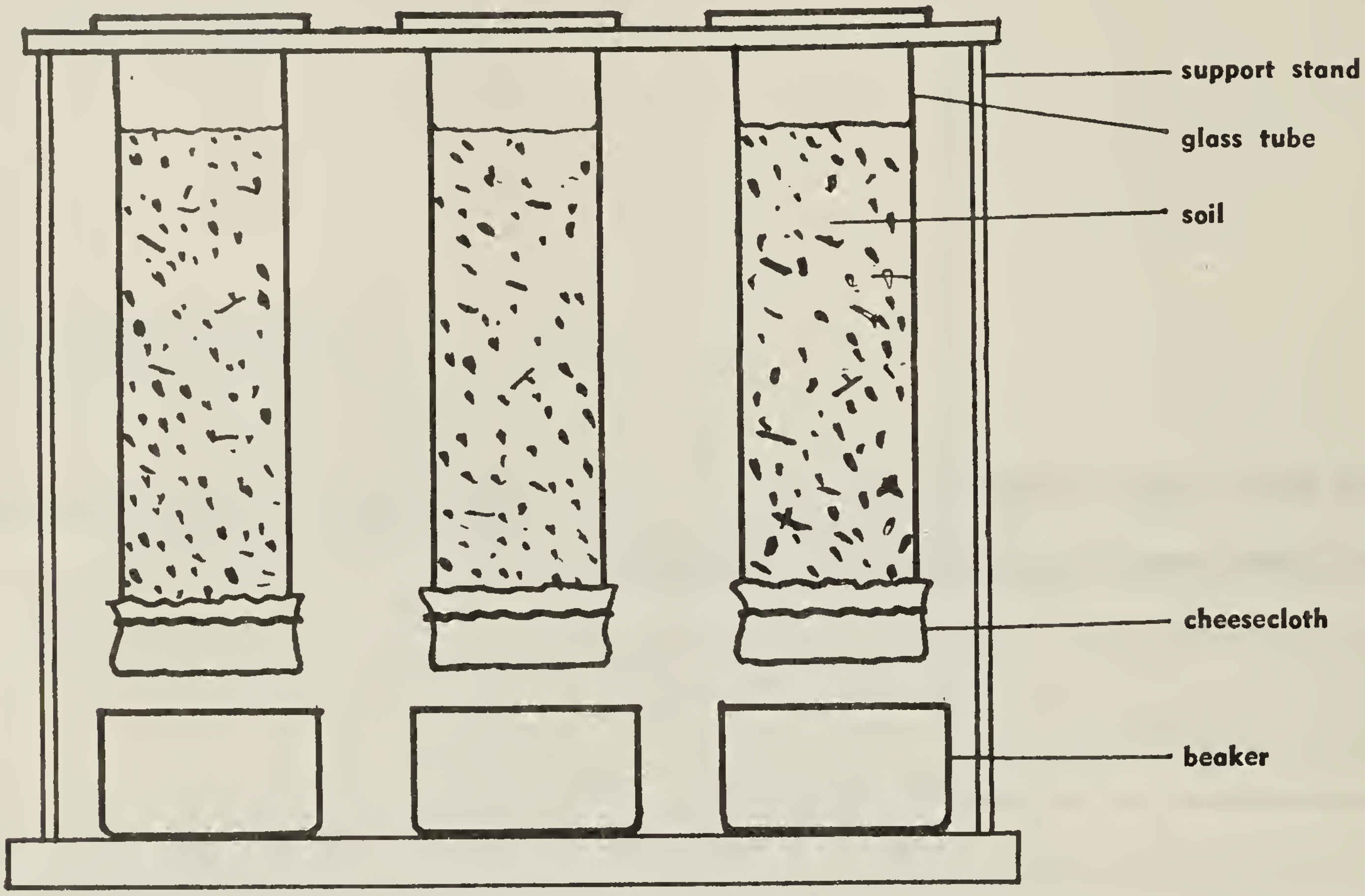
What factors seem to cause erosion at this place?

Could this erosion have been prevented by conservation methods? Explain

Suggest steps that might be taken to prevent or minimize future erosion at this place

L 9. WATER HOLDING

Set up three open-ended glass tubes as shown in the diagram. Lightly tamp air-dried loam in tube A, sand in tube B, and clay in tube C. Have the same depth of soil in each tube. Add measured amounts of water to each tube until water drips from the bottom. When water stops dripping from the bottom of the tube measure the amount collected below each tube.



Observation

A. LOAM

Amount of water added ______; collected ______; retained ______

B. SAND

Amount of water added ______; collected ______; retained ______

C. CLAY

Amount of water added ______; collected ______; retained ______

Which type of soil has the greatest water holding capacity? ______

Which type of soil has the least water holding capacity? ______

Which of these soils would be a cold soil? ______

Why? ______

______

______

______

CELLS AND TISSUES

L 10. PLANT CELLS

Materials

Microscope, slide, cover slip, scalpel, forceps, dilute iodine solution, onion bulb.

Procedure

Cut the onion into quarters. Peal off one scale. With the forceps strip off a piece of the thin skin from the inside of the scale. Place a piece about one quarter inch long in a drop of water on the slide and cover with a cover slip. Keep it flat.

Place the slide on the stage of your microscope and focus the onion skin under low power. (FOLLOW CAREFULLY THE INSTRUCTIONS FOR USE OF THE MICROSCOPE, PAGE 5.) Observe the CELLS carefully.

Remove the slide from the microscope. Lift the cover slip and place a drop of iodine solution on the slide. Replace the cover slip and focus under low power again. Select a particularly clear cell, move the slide until it is in the center of the field, then switch to high power.

Identify the following structure in the cell:

(a) The CELL WALL—the boundary of the cell.

(b) The NUCLEUS—a small darkly-stained oval body.

(c) The CYTOPLASM—the protoplasm outside the nucleus. This is bounded by the plasma membrane which is pressed against the cell wall.

(d) The VACUOLE—a large clear space filled with a clear liquid.

Observations and Drawings

Draw five or six cells as seen under low power to show their arrangement. Use double lines for the walls to show the thickness. Make lines clear and definite. Draw one cell as seen under high power. Make your drawings large and label clearly the structures listed.

Define a cell.

Who gave it this name?

What have you observed about onion skin?

Onion skin is epidermal tissue. Define a TISSUE.

State the CELL THEORY.

Who first stated this theory?

L 11. ANIMAL CELLS

Materials

Microscope, slide, cover slip, clean scalpel, iodine or methylene blue stain.

Procedure

Gently scrape the inside of your cheek with the scalpel. Place a drop of water on the slide and tap the scalpel in it to dislodge any material collected on it. Add a drop of the stain and cover with the cover slip.

Examine this slide under low then high power as you did with the onion skin.

Observations and Drawings

Compare the structure and arrangement of these cells with those of the onion skin, noting particularly any structures present in the one and not in the other. Draw a bit of the tissue consisting of several cells as seen under low power.

Draw one cell as seen under high power and label all structures seen.

Low Power **High Power**

What have you observed about the structure of the human cheek lining? ....

....

These are typical cells of EPITHELIAL TISSUE.

What is the function of epithelial tissue? ....

....

From your observations of the onion skin and cheek epithelium explain the fundamental similarities and differences between plant and animal cells. ....

....

....

....

....

....

....

L 12. CELL DIVISION (MITOSIS)

Materials

Prepared stained slides of onion root tip, whitefish, or Ascaris showing mitosis. Microscope.

Procedure

A characteristic of living matter is its ability to grow and reproduce. To do so, cells must divide. In the simplest plants and animals this division is a comparatively simple process but in higher organisms it involves a sequence of complex changes. On these slides are cells that have been killed and fixed in various stages in this sequence. The slides have been stained to make the details of structure stand out clearly.

Locate under low power a cell in each of the stages described here, then switch to high power and observe the structures mentioned. Draw one cell in each stage in the space provided. Label fully.

1. PROPHASE. Locate a cell in which the chromatin granules have fused to form a long, slender, coiled thread, the SPIREME.

Locate another cell in which the spireme has separated into distinct rod-like segments. These are called **chromosomes.** Each chromosome is a double strand, but your magnification is not likely to be great enough to enable you to see this. The nucleolus and nuclear membrane are less distinct than in the cell observed previously. If you are examining an animal cell you may be able to make out two tiny CENTROSOMES.

2. METAPHASE. Locate a cell in which the nuclear membrane and nucleolus have disappeared and the chromosomes have migrated to the equator of the cell and arranged themselves in a ring. You may be able to see fine threads, the SPINDLE FIBRES, stretching from the poles of the cell to the equator, where one attaches to each half of a chromosome.

3. ANAPHASE. Locate a cell in which half of each split chromosome has been pulled along a spindle fibre towards the poles. One half of each chromosome goes to one pole, the other half to the opposite pole. These form two groups of V-shaped chromosomes.

4. TELOPHASE. Locate a pair of cells, identical in appearance and about half the size of large cells. The chromosomes in the group at each pole have formed a new nucleus with a nuclear membrane and nucleolus, and a wall or membrane has developed between the new nuclei to form two daughter cells. Individual chromosomes can not be seen. If these cells were living they would now absorb water and grow in size.

Observations and Drawings

1. Early Prophase **Late Prophase**

2. Metaphase **3. Anaphase**

4. Telophase

How does the number of chromosomes in the daughter cells compare with the number in the mother cell? --

----

How does the number of chromosomes in the cells of different body tissues of a multicellular organism compare? --

----

THE GREEN PLANT AND FOOD PRODUCTION

L 13. STRUCTURE OF A FLOWERING PLANT

(Other plants are dealt with under **Reproduction**)

Materials

A wild mustard or shepherd's purse plant—a live plant, or a pressed and mounted specimen.

Procedure

Examine the plant carefully, then answer the questions and draw the entire plant. Make all lines clear and definite. Label your drawing carefully.

Observations

1. ROOT. The main root is called the PRIMARY ROOT and the branch roots are called LATERAL ROOTS.

What are the three chief functions of roots?

(a) ______________________________

(b) ______________________________

(c) ______________________________

How does the total length of root compare with the total length of stem? ______________________________

____

Of what advantage is so much root to a plant? ______________________________

____

____

____

2. STEM. Notice the main axis, secondary axis, nodes, internodes, and leaf axils.

State three chief functions of stems.

(a) ______________________________

(b) ______________________________

(c) ______________________________

3. LEAF. Notice the blade, petiole, midrib, and veins. The arrangement of leaves on a stem is either opposite, alternate, or spiral. Which a arrangement has this plant? ______________________________

What are the three chief functions of leaves?

(a) ______________________________

(b) ______________________________

(c) ______________________________

4. FLOWER. This plant belongs to the Cruciferae family. The flowers of this family have four tiny petals in the form of a cross. The cluster of flowers is called an INFLORESCENCE. The stalk of the inflorescence is the PEDUNCLE, the stalk of each individual flower the PEDICEL.

5. FRUIT. The fruit of this plant is a pod. It is a ripened ovary. Break open a mature pod and observe the seeds. They are ripened ovules.

Where are the seeds attached? ______________________________

How are the seeds scattered? ______________________________

____

Why is this plant so widely distributed? ______________________________

____

Make a large drawing of the plant and label all of the parts.

L 14. AN ANGIOSPERM LEAF

Materials

Dried or live leaves of three different kinds of plants, a fresh geranium leaf, cross-sections of an alfalfa or bean leaf, slide, cover slip, scalpel, forceps, microscope.

Procedure and Observations

1. Observe the petiole, size, shape and margin of blade, midrib and venation. Draw one leaf of each kind.

2. Put a large drop of water on the slide. Hold the live geranium leaf tightly over your forefinger with the under side out. Scrape the surface carefully with a sharp scalpel so as to fray up a bit of the epidermis. Catch the frayed edge with the forceps and strip off a piece of the epidermis. This should be colorless. Place a small piece of this in the water on your slide. Be careful not to let it double over. Place a cover slip on the slide and examine it under low power.

Notice that most of the cells are colorless and irregular in shape. These are epidermal cells. Notice that each is surrounded by a wall and contains cytoplasm and a nucleus. Here and there are tiny dark areas. Each dark spot is actually a tiny opening between two bean-shaped GUARD CELLS. The opening is called a STOMA or STOMATE. The guard cells contain small green bodies called CHLOROPLASTS.

Are chloroplasts present in the epidermal cells? ....

If your magnification is 100X, the area of the field in view is about 3.5 sq. mm. How many stomates do you estimate are present per square centimeter? ....

What is the function of the stomates? ....

....

....

If time permits, compare the size of the stomates in a strip taken from a leaf that has been in direct sunlight with one that has been in the dark for an hour or more.

Why is it necessary that the epidermis be transparent? ....

....

Draw two guard cells and the ordinary epidermal cells adjacent to them. Show the cell walls and all of the cell contents mentioned above accurately. Label fully.

3. Study the cross-section of bean or alfalfa leaf under the low power of your microscope.

Observe:

(a) EPIDERMIS. Upper and lower, each a single layer of cells. Notice the stomates and their guard cells, and the cuticle covering the epidermis.

What is the function of the cuticle? ____

____

(b) MESOPHYLL. The middle part of the leaf is made up of parenchyma cells containing numerous chloroplasts. Those near the upper epidermis, usually a single layer, are long, slender, cylindrical cells close together. This is the PALISADE LAYER. Between the palisade layer and the lower epidermis the cells are more irregular in shape with much INTERCELLULAR AIR SPACE. This is the SPONGY PARENCHYMA.

(c) VEIN. Observe a vein in cross-section. Notice the thick-walled cells in the upper half. These are XYLEM cells.

What is their function? ____

____

The thin-walled cells in the lower part of the vein are PHLOEM cells. The large rectangular ones are SIEVE TUBES and the small ones between them with prominent nuclei are COMPANION CELLS.

What is the function of the phloem? ____

____

The vein is surrounded by a SHEATH of fairly thick-walled, round cells, one function of which is to protect the vein.

Draw a narrow strip of the cross-section including a vein and at least one stomate. Do not attempt to draw too many cells. Show the details of the structure of all cells accurately. Label fully.

A Small Part of a Cross-section of ______________________ Leaf

L 15. ANGIOSPERM ROOT

Materials

Wheat or radish seeds, blotters, Petri dishes, hand lens, longitudinal-section of a root tip, cross-section of a root, microscope.

Procedure

Place some wheat or radish seeds between moist blotters in a Petri dish and leave in a warm place for a few days to germinate. When the roots are about an inch long examine them with a hand lens.

Observation

Observe the fine white thread-like structures which give the root a fuzzy appearance. These are ROOT HAIRS.

Where do the root hairs occur on the root? Do they extend right to the tip? ____________________

____

Draw a seedling. Show the location of the root hairs accurately.

Why do you not see root hairs on a root that has been pulled out of the ground? ____________

____

____

Procedure

Examine the longitudinal section of a root tip under low power. Observe the ROOT CAP over the tip made up of rather thick-walled, empty cells. Immediately behind the cap observe the GROWING POINT made up of small thin-walled cells with prominent, densely stained nuclei. This is the REGION OF CELL MULTIPLICATION. The part of the root where root hairs are seen is the REGION OF MATURATION. The part between this region and the growing point is the REGION OF ELONGATION.

Draw the section and label the regions. Show cell details accurately in the right half of the drawing.

What is the function of the root cap? ________________________________

____

What is the function of the root hairs? ________________________________

____

Where does growth in length of the root occur? ____________________________

____

Why cannot growth in length occur in the region of maturation? _______________

____

____

Procedure

Examine the root cross-section under low power.

Observations

(a) EPIDERMIS. This is the outermost layer of cells.

Do these cells have nuclei? ________________________________

Observe that each root hair is a single elongated epidermal cell.

(b) CORTEX. The cortex is the region, several cells thick, next to the epidermis. It is made up of round, thin-walled parenchyma cells with some intercellular spaces. Some cells may contain starch grains.

(c) ENDODERMIS. If your section is not from too near the tip, you will observe a conspicuous ring of cells with inner and side walls thickened. In the older region, the endodermis probably prevents excessive loss of water to the cortex.

(d) PERICYCLE. This is a single layer of thin-walled cells next to the endodermis which retain the ability to divide. Lateral roots arise from this layer. In old roots this layer produces cork and the outer tissues are not present.

(e) XYLEM. This is the wood tissue made up of thick walled cells of two types, large tracheal tubes or VESSELS and smaller TRACHEIDS. In many dicotyledons the xylem is in the form of a cross. In monocotyledons it lies outside a cylinder of PITH. Its function is to conduct water and dissolved raw materials away from the root.

(f) PHLOEM. This tissue is composed of bundles of cells between the xylem. It is composed of large, thin-walled, empty SIEVE TUBES and small COMPANION CELLS, with nuclei between them. Its function is to transport manufactured food in solution.

Draw a narrow sector of the cross-section on a large scale. Show the arrangement of the tissues and the types of cells that make up each. Label fully.

L 16. ANGIOSPERM STEMS

Materials

Stained cross-sections of corn stem, alfalfa stem, and basswood stem. Microscope.

Observations

1. Examine the section of alfalfa stem under low power.

(a) EPIDERMIS. This is the outermost layer of cells. Draw a few epidermal cells showing their shape, arrangement and details of structure.

(b) CORTEX. This is made up of several layers of parenchyma cells and some intercellular spaces. Do any of these cells contain chloroplasts? ______________________________

Draw a few cortex cells to show shape, arrangement, and details of structure.

(c) PHLOEM. This tissue is the outermost part of each FIBROVASCULAR BUNDLE. It is made up of empty SIEVE TUBES which tend to be arranged in rows, and small COMPANION cells with nuclei, between the sieve tubes.

(d) XYLEM. This is the innermost tissue of each fibro-vascular bundle. It is made up of empty thick-walled cells, large VESSELS and smaller TRACHEIDS. The cells are in rows.

(e) CAMBIUM. This is a layer of thin-walled cells, with nuclei, lying between the phloem and the xylem.

Draw a small fibro-vascular bundle showing accurately the shape, size, and arrangement of cells of the phloem, xylem and cambium. Label fully.

What is the function of the phloem?

What is the function of the xylem?

What is the function of the cambium?

Account for the phloem and xylem cells being arranged in rows.

(f) RAY. This is made up of rows of parenchyma cells separating the fibro-vascular bundles. What is its function?

(g) PITH. This is the center core of thin-walled parenchyma cells. What is its function?

Draw a sector of the cross-section of the alfalfa stem including one bundle. Show shape, relative size, and arrangement of the cells in each tissue. Label fully.

2. Examine the cross-section of basswood stem under low power. Identify the tissues corresponding to those studied in the alfalfa stem.

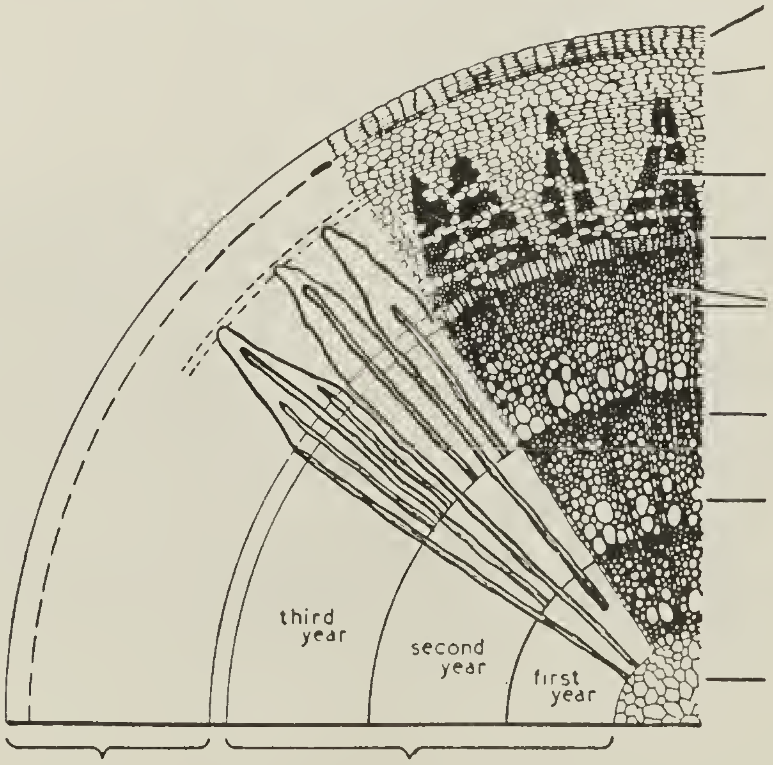
Account for the annual rings.

How many years of growth are represented in the stem you are studying?

How does the amount of pith present compare with that at the end of the first year?

Account for the triangular shape of the sections of phloem.

Label all of the structures indicated in this diagram of a woody dicot stem.



3. Examine the cross-section of the corn stem. This is a typical monocotyledon stem. Most of the tissue of this stem is made up of parenchyma cells. Is there a clear division of these cells into cortex and pith?

How does the size and arrangement of the fibro-vascular bundles compare with that in the alfalfa stem? ____

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Make a diagram of the cross-section to show the arrangement of the bundles and other tissues. You need not show details of cells.

Study one bundle in detail under both low and high power. Observe:

(a) The SHEATH, made up of one or more layers of thick-walled cells around the bundle.

(b) XYLEM. Usually three large vessels in the form of a V with an irregularly shaped air space at the vertex, and xylem parenchyma between them. There are tracheids near the air space.

(c) PHLOEM. This consists of eight-sided, thin-walled SIEVE TUBES each in contact with four small COMPANION CELLS. Some bast fibres are seen at the outer edge of the phloem.

Draw one bundle as seen under high power. Show details of cells accurately. Label fully.

PLANT PHYSIOLOGY

L 17. DIFFUSION

Materials

Ammonia, carbon tetrachloride or carbon disulfide, red ink, potassium permanganate, large beaker, pipette.

Procedure

1. Place stoppered bottles of ammonia and the other volatile substances on table. Remove the stoppers and have pupils in various parts of the room record the time it takes the odor of each to reach them.

2. Fill the beaker with water and allow to stand for five minutes. With the pipette, carefully place a large drop of red ink in the center of the beaker.

3. Drop a large crystal of potassium permanganate in a beaker of water.

Observations

Describe and explain in detail on the basis of the molecular theory what happened in each part of the experiment.

Define diffusion

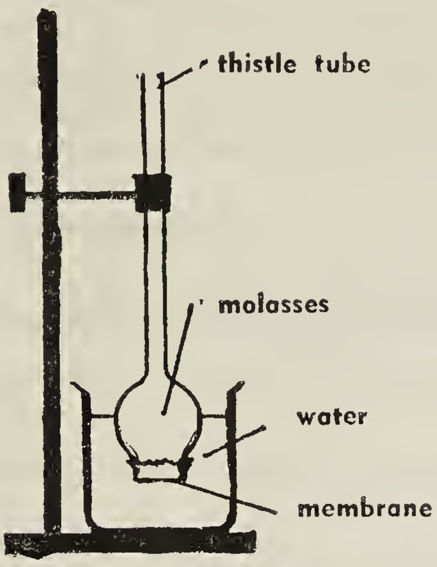
L 18. OSMOSIS

Materials

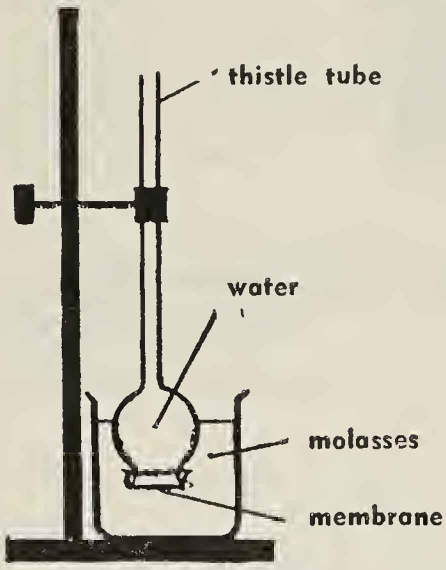
Three thistle tubes, three beakers, three support stands, differentially permeable membranes (pig's bladder or non-waterproof cellophane), molasses, starch, iodine, Fehling's solution.

Procedure

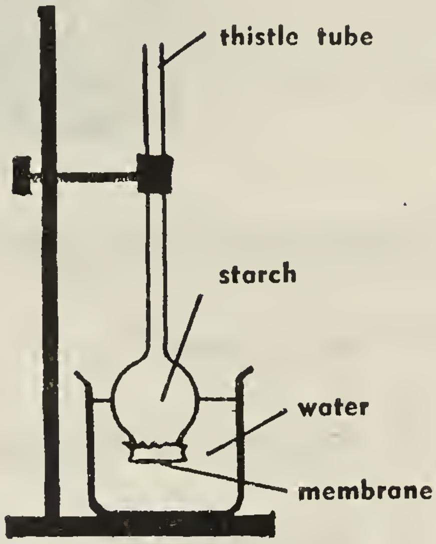
Set up apparatus as shown in the diagram. Use a rubber band to hold the membrane in place.



A



B



C

Observation

Note the original height of the liquid in each thistle tube and the height at two other times later in the day. Mark these levels on the diagram.

Thistle tube A

Thistle tube B

Thistle tube C

At the conclusion of the experiment test some of the water from beaker A with Fehling's solution.

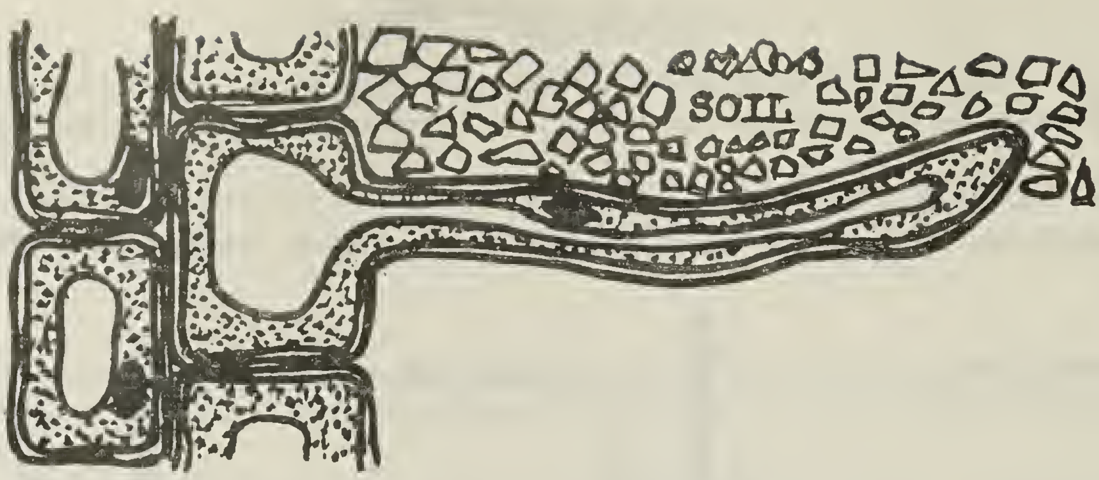
Result?

Test some water from Beaker C with iodine. Result?

Explain in detail what has happened in each tube, in terms of diffusion.

Define osmosis

What determines which direction the water moves through the membrane?



In the root-hair cell in the diagram, what corresponds to:

(1) the molasses?

(2) the water in the beaker?

(3) the membrane?

In which direction will there be the greatest movement of water molecules? Why?

Why don't the sugar molecules leave the cell for the same reason?

What would happen if salt water were put in the soil around the root of a plant?

Label on the above diagram the parts referred to and indicate with arrows the direction of movement of water.

L 19. OSMOSIS (Optional)

Materials

A large, firm carrot, a 1-holed No. 5 rubber stopper, long glass tubing to fit stopper, battery jar, support stand, molasses, 1-inch wood auger.

Procedure

With the wood auger bore a hole two to three inches deep down the center of the carrot. Fit one end of the glass tube through the rubber stopper. Fill the cavity in the carrot with molasses to which a little water has been added. Fit the stopper in the top of the carrot, and support the carrot and tube in a battery jar of water so that the carrot is completely under water. Observe from time to time for 48 hours.

Observation

Draw the apparatus as set up in this experiment. Label all the parts and indicate the original and final height of the liquid in the tube.

Explain in detail what has happened in this experiment. ____________________

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What is meant by root pressure? What causes it? ____________________

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PHOTOSYNTHESIS

Materials

Geranium plant, Coleus plant, Elodea plant (or other green water plant), thin cork discs, pins, beakers, iodine, methyl alcohol.

L 20. IS LIGHT ENERGY NECESSARY FOR PHOTOSYNTHESIS?

Procedure

Place a geranium plant in a dark cupboard and leave it there until the next day. Remove one leaf from the plant and place it in boiling water to kill and rupture the cells.

Place a thin cork disc on each side of another leaf. Fasten the discs together opposite one another with a pin through the leaf. Then place the plant so that this leaf is in direct sunlight for an hour or more. Remove the leaf from the plant and remove the corks, then boil the leaf in water. Place both leaves in alcohol and leave until all color has been removed. This process may be hastened by warming the alcohol over a water bath. (CAUTION: DO NOT HEAT ALCOHOL OVER AN OPEN FLAME SINCE IT IS HIGHLY INFLAMMABLE.) When the leaves are white, or nearly so, place them in a shallow dish and rinse with water, then flood with dilute iodine.

Observation

Draw both leaves and indicate the colors: (1) when they were removed from the plant; (2) after flooding with iodine.

What does blue color in the presence of iodine indicate? ______________________

____

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Why did the first leaf not turn blue? ______________________

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____

Why did all of the second leaf turn blue except the part under the cork discs? ____________

____

____

Conclusion ____

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L 21. IS CHLOROPHYLL NECESSARY FOR PHOTOSYNTHESIS?

Procedure

Leave a Coleus (or other variegated plant) in a dark cupboard overnight, then remove a leaf and put in boiling water as was done in the previous experiment. Place the plant in direct sunlight for an hour or more, then remove another leaf and place it in boiling water. Remove the pigment from both leaves with alcohol, rinse, and flood with dilute iodine.

Observation

Draw two diagrams of each leaf. In one show the colors in the leaf when it was first removed from the plant. In the other the colors after flooding with alcohol.

Why is there no blue color in the first leaf after adding iodine?

Why is there blue color in part of the second leaf and not in another part?

Conclusion

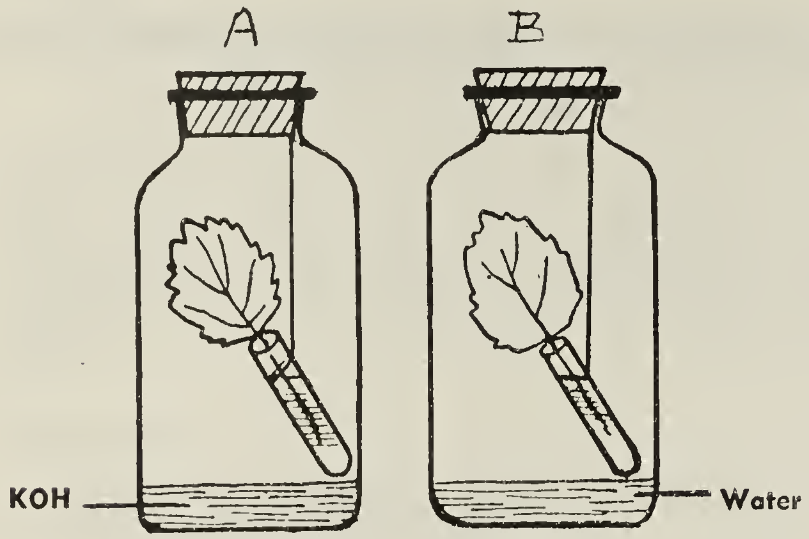
What had become of the starch manufactured in the green parts of the geranium and Coleus leaves before they were put in the dark?

This may be verified by removing a leaf blade from the plant after it has been in light and placing it in cold water in a beaker, then placing both the beaker and the plant in dark overnight and testing this leaf and another one for starch in the morning.

L 22. IS CARBON DIOXIDE NECESSARY FOR PHOTOSYNTHESIS? (Optional)

Procedure

Take two leaves from a geranium plant that has been in the dark for at least 24 hours. Place each leaf with its petiole in a small vial of water. Support one vial in a wide mouthed bottle "A" which has about half an inch of potassium hydroxide solution in the bottom, and the other vial in a similar bottle "B", with just water in the bottom. Tightly stopper both bottles and place them in direct sunlight for an hour or more. Test the leaves for starch.



What is the purpose of the KOH in bottle "A"?

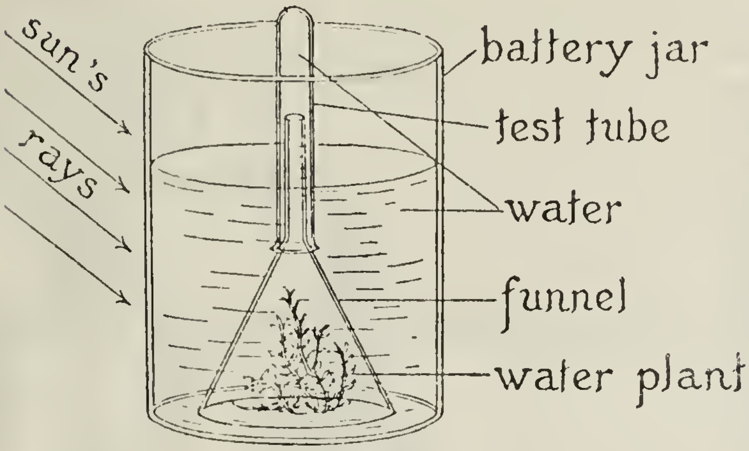
Observation

Conclusion

L 23. IS OXYGEN RELEASED DURING PHOTOSYNTHESIS?

Procedure

Bubble carbon dioxide into water containing Elodea in a battery jar. Place funnel over the plant as shown in the diagram, then fill a test tube with water and invert it over the neck of the funnel. Leave the apparatus in direct sunlight for several hours. Test the gas that has collected in the test tube with a glowing splint.



Observations

What happened when the glowing splint was in strong sunlight? ______________________

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What happened when the glowing splint was lowered into the test tube? ______________________

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Conclusion ______________________

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The first staple product of photosynthesis that can be detected is the simple sugar glucose. The balanced chemical equation for the process can be expressed thus:

$$6H_2O + 6CO_2 + \text{radiant energy} \longrightarrow C_6H_{12}O_6 + 6O_2$$

Express this process in a word equation without using symbols. ______________________

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The plant can use the glucose in the synthesis of other organic compounds such as more complex sugars, starches, proteins, fats, vitamins, enzymes, acids, latex, pigments, alkaloids, perfumes.

Explain what is meant by a BALANCED AQUARIUM. ______________________

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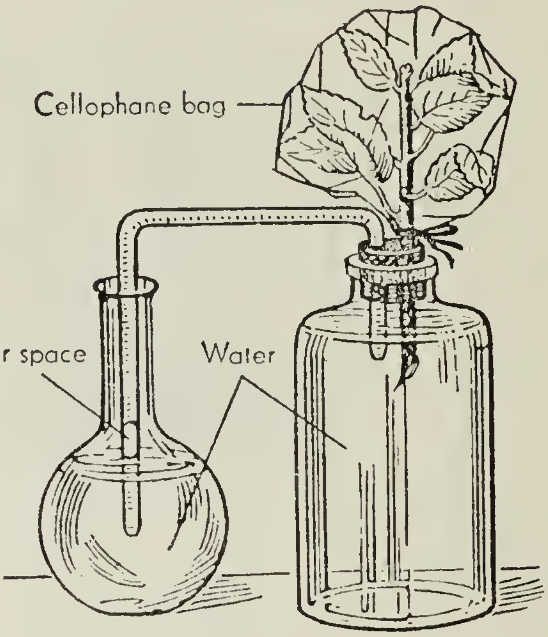
L 24. TRANSPIRATION

Materials

Coleus or geranium plant, bottle, flask, glass tubing, 2-holed rubber stopper, vacuum wax, water-proof cellophane.

Procedure

Set up the appartus as in the diagram. To get the stem through the stopper without damaging it, insert a wet cork-borer or glass tube slightly larger than the stem through the stopper from the bottom. Then insert the end of the stem in this tube and gently pull both tube and stem through the stopper. Seal around the stem with vacuum wax if necessary. Insert the glass tube in the other hole of the stopper, fill the tube and the bottle with water, then press the stopper in place so that some water is forced through the tube. Place the apparatus in bright light until a small air bubble is seen in the tube, then place the end of the tube in the water in the flask and observe the air bubble and the inner surface of the bag from time to time.



Observations

Where did the water on the inside of the bag come from?

How did it get out of the plant?

How did it get from the bottle to the leaves?

Conclusion

State clearly three factors that would have a part in lifting the water from the root of a plant to the leaves.

(1) ....

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(2) ....

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(3) ....

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Describe five factors affecting the rate of transpiration in plants.

(1) ....

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(2) ....

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(3) ....

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(4) ....

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(5) ....

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Describe five adaptations in plants that reduce transpiration

(1) ....

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(2) ....

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(3) ....

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(4) ....

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(5) ....

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L 25. ELEMENTS ESSENTIAL TO PLANTS (Optional)

Materials

Clean flower pots, coffee cans, rain or distilled water, thoroughly washed fine gravel or zonolite, wheat seeds, and chemically pure calcium nitrate, potassium chloride, potassium phosphate, magnesium sulfate, ferrous sulfate, calcium chloride, potassium nitrate, sodium phosphate.

Procedure

Germinate about 100 wheat seeds, until roots are about half an inch long.

Make up the following solutions in clean flasks. Use 1 liter of rain water or distilled water in each case.

Sol. No.	Compounds Present and Quantity					Element Lacking
	1 g.	0.25g	0.25g	0.25g	0.1g	
1.	$Ca(NO_3)_2$	KCl	K_3PO_4	$MgSO_4$	$FeSO_4$	
2.	$CaCl_2$	KCl	K_3PO_4	$MgSO_4$	$FeSO_4$	
3.	KNO_3	KCl	K_3PO_4	$MgSO_4$	$FeSO_4$	
4.	$Ca(NO_3)_2$	$CaCl_2$	Na_3PO_4	$MgSO_4$	$FeSO_4$	
5.	$Ca(NO_3)_2$	KCl	K_3PO_4	$MgSO_4$	—	
6.	$Ca(NO_3)_2$	KCl	—	$MgSO_4$	$FeSO_4$	
7.	Distilled water only.					

Fill the pots with fine gravel or zonolite and plant ten seedlings in each. Place each pot in a coffee can and add one solution to each pot until the level in the can is about an inch below the seeds in the pot. Add more from time to time to maintain the level. Place the plants in strong light for several weeks.

Observations

Observe the growth of the plants and their appearance periodically and record your observations.

Conclusion

What other elements not included in this experiment are essential for plant growth?

L 30. WHAT IS THE EFFECT OF PEPSIN ON PROTEIN?

Materials

Hard boiled egg, water, pepsin, hydrochloric acid, petri dishes. The egg may be boiled in the shell, then cut into very thin slices, or the white may be put in a beaker and then sucked up into a long glass tube, then the glass tube dropped into boiling water. When the egg white is cooked remove the tube from the water and allow it to cool, then score it with a file and break into one-inch segments.

Procedure

1. Take four petri dishes and label them A, B, C and D. Place a thin slice or a short tube of egg white in each.
2. To dish A add water until about three quarters full.
3. To dish B add very dilute (about 0.5%) hydrochloric acid.
4. To dish C add water to which pepsin has been added (about 2 g. per 100 ml.)
5. To dish D add water, hydrochloric acid and pepsin in the amounts used in dishes A, B, and C.
6. Place the four dishes in a warm place for 24 hours. Use an incubator if you have one. Record the appearance of each in the table.

Observations

Dish	Contents	Results After 24 Hours
A		
B		
C		
D		

The soluble products here are peptones.

Conclusion ______________________________

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Where does pepsin come from? ______________________________

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Gastric fluid also contains RENNIN. What is the function of rennin? ______________________________

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L 31. WHAT EFFECT HAS PANCREATIC FLUID ON FOOD? (Optional)

Materials

Commercial pancreatin, commercial bile salts, starch, hard-boiled egg, olive oil, six test tubes.

Procedure

Dissolve 1 g. of pancreatin and 2 g. of bile salts in 100 ml. of warm water.

1. Place a little starch in test tubes A and B. Half fill test tube A with the pancreatic solution, and test tube B with warm water.

2. Place egg white in test tubes C and D. Half fill test tube C with the pancreatic solution, and test tube D with warm water.

3. Put a few drops of olive oil in test tubes E and F. Half fill test tube E with the pancreatic solution and test tube F with warm water.

4. Leave all six tubes in a warm place for 24 hours or longer if necessary. Observe and record results below. Test part of the contents of test tubes A and B for starch and for sugar.

Observations

Tube	Contents	Results After 24 Hours
A		
B		
C		
D		
E		
F		

Conclusion ______________________________

____

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Give the names of three enzymes in pancreatic fluid, the food digested by each, and the end product.

(1) ______________________________

(2) ______________________________

(3) ______________________________

METABOLISM

Define metabolism. ______________________________

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What processes does it include? ______________________________

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L 28. ADAPTATIONS FOR FOOD GETTING AND HOLDING

Observe adaptations for food getting and holding in as many animals as possible. List the animals and the adaptations.

Define digestion ______________________________

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WHAT IS THE EFFECT OF SALIVA ON STARCH?

Materials

Boiled starch, test tubes, saliva, iodine solution, Fehling's solutions A and B.

Procedure

Put about an inch of boiled starch in each of two test tubes, A and B. Add saliva to tube A. Add pure water to tube B to bring it to the same level as tube A. Shake both tubes, then let them stand in a warm place for two hours or until next day. Pour a little of the contents of tube A into a clean test tube and test for starch. Do the same with tube B. Pour a little from tube A into another clean test tube and test for sugar. Do the same with tube B.

Observations

	Starch	Sugar
Tube A		
Tube B		

Conclusion ______________________________

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What was the CONTROL in this experiment? ______________________________

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The active enzyme in saliva is ptyalin. It converts starch into maltose sugar. Where does the ptyalin secreted by the salivary glands come from? ______________________________

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L 26. FOOD NUTRIENT TESTS

Materials

Test tubes, crucible, corn starch, glucose or dextrose, egg white, fat, chalk, dilute iodine solution, Fehling's solution A and B, nitric acid, ether, unglazed paper.

Procedure

1. Take four test tubes. Place a small sample of starch in one tube, sugar in the second, egg white (protein) in the third, and fat in the fourth. Add a few drops of dilute iodine solution to each. Record observations in the table below.

2. Repeat the above, but add about an inch of each Fehling's (A and B) solution to each tube instead of iodine. Then heat the tube. (Only sugars that reduce the copper give this reaction.)

3. Repeat the above, but add about an inch of dilute nitric acid to each tube (CAUTION), then heat gently. DO NOT BOIL. Observe, then add a small amount of ammonium hydroxide to each.

4. Smear a small amount of fat on a piece of unglazed paper, then hold the paper up to the light. Some foods can be tested for fat in this way by simply rubbing it on unglazed papers. A better method is to grind the food in a mortar, then put in a test tube with some ether and shake vigorously. Then filter quickly. Place a drop of the filtrate on unglazed paper and observe after the ether has evaporated.

5. Place a piece of chalk (mineral matter) in a crucible and heat as hot as possible. Repeat with a few wheat seeds. Any gray ash left is mineral matter.

6. Substances may be tested for the presence of water by placing a small amount in a test tube and heating the bottom of the tube gently while keeping the top as cool as possible. If water is driven out of the substance tiny drops will collect on the top of the tube.

Summary of Observations

Nutrient	Test Used	Result
Starch		
Glucose		
Protein		
Fat		
Mineral Matter		
Water		

Conclusion: State how you would analyze a given sample of food. ____________________

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L 27. STORED FOOD IN PLANTS

Materials

The testing materials used in the preceding experiment; potato, corn kernels, apple, grapes or raisins, Brazil nut, bean.

Procedure

Test each sample as indicated in the preceding experiment and record the results in the table:

Observations

Sample	Nutrients Present					
	Starch	Sugar	Protein	Fats	Mineral	Water
Potato						
Corn						
Apple						
Grape						
Brazil Nut						
Bean						

Conclusion: In what parts of plants are various food nutrients stored? ______________________

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Examine scrapings from a bean, corn and potato under the microscope. Note the starch GRAINS.

Do you find a characteristic type of starch grain common to all? ______________________

Do you find a type of starch grain characteristic to each plant? Draw one.

Give the names of three enzymes secreted by the intestinal glands, the food digested by each, and the end products.

(1) ______________________________

(2) ______________________________

(3) ______________________________

L 32. DO PLANTS PRODUCE DIGESTIVE ENZYMES?

Materials

Barley seeds, hard-boiled egg, iodine, Fehling's solutions A and B, test tubes, mortar and pestle.

Procedure

1. Take about 200 barley seeds. Germinate half of them between wet blotters or paper towels untils the shoots are about an inch long.

2. Grind the germinated seeds in the mortar and put the ground material in a test tube and add water. Shake the tube vigorously. Do the same with the dried seeds.

3. Test a little of the material from each test tube for starch and a little for sugar.

4. Allow the solid material remaining in the test tubes to settle, then decant the liquid part into two clean test tubes. To each add a little egg white, and leave in a warm place for two or three days. Observe the egg white.

Observations

	Starch	Sugar (Maltose)
Dried barley seeds		
Sprouted barley		

Has any change occurred in the egg white in the liquid from the tube with the dried seeds?

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From the tube with the sprouted seeds? ______________________________

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Conclusion ______________________________

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The enzyme that digested the starch to maltose is a DIASTASE. The enzyme that digested the protein is a PROTEASE.

L 33. AMEBA

Materials

Stained ameba mounted on a slide. Microscope.

Observations

1. SHAPE. Account for the lack of uniformity in shape.

2. STRUCTURE.
   - (a) CELL MEMBRANE. This is a thin, invisible, differentially permeable membrane separating the protoplasm from its environment. In mature plant cells it is usually surrounded by a wall while in animal cells in general there is no wall.
   - (b) A dark, spherical mass of protoplasm is seen near the center of the cell. This is the NUCLEUS.
   - (c) CYTOPLASM. This includes all of the protoplasm between the nucleus and the cell membrane. It consists of two rather distinct portions: an outer, clear, translucent layer, the ECTOPLASM; and a granular central portion, the ENDOPLASM. Within the endoplasm look for FOOD VACUOLES containing dark food particles surrounded by a clear area. There may also be clear round CONTRACTILE VACUOLES.
   - (d) PSEUDOPODIUM. Each is a finger-like projection of the protoplasm.

Draw one ameba on a large scale. Label the parts named above.

How does an ameba ingest food?

What is the function of the food vacuole?

What is the function of the contractile vacuole?

How does an ameba move?

If a live culture of ameba is available observe locomotion, feeding, and excretion under the microscope.

L 34. PARAMECIUM

Materials

A permanent mount of stained paramecium, slides, cover slips, pipette, hay infusion, microscope.

Note: A hay infusion may be made by placing a handful of hay or dried grass in a battery jar and adding water to a depth of one inch. Leave in a warm room. Add water from day to day increasing the depth a little. The infusion will be swarming with bacteria in a day or so and a few days later paramecia and other protozoans will usually be found in great numbers.

Observe the stained specimen of paramecium. Notice the uniformity of shape. Observe:

(1) CELL MEMBRANE—More definite than in ameba.

(2) TRICHOCYSTS—Stiff, needle-shaped structures just inside the membrane.

(3) ORAL GROOVE—A spiral-shaped depression about the middle of the animal. At the bottom of the groove is the temporary mouth.

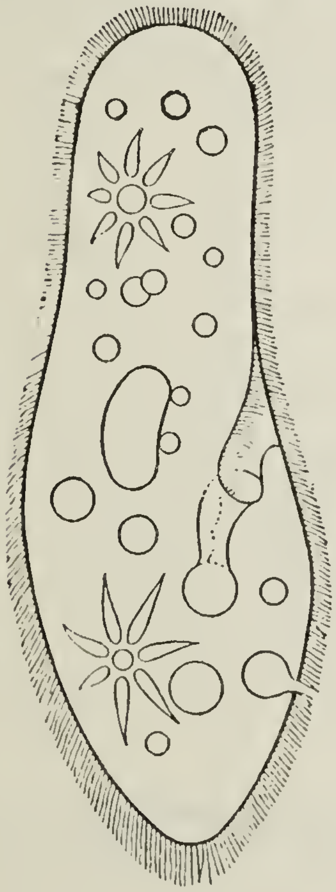
(4) CYTOPLASM—Consists of ectoplasm and endoplasm.

(5) NUCLEUS—A large MACRONUCLEUS and a small MICRONUCLEUS.

(6) VACUOLES—Numerous FOOD VACUOLES and two CONTRACTILE VACUOLES.

(7) CILIA—Many short, hair-like outgrowths of the ectoplasm.

Label on this diagram the nine structures mentioned above.



Using the pipette place a drop of material from the top or side of the hay infusion on a slide. Place a cover slip over it, and examine it under low power. Search for paramecia. They may be caused to slow up by placing a few threads of finely teased lens paper on the slide. How do the paramecia move? ____________________

____

____

What happens when one bumps into an obstacle? ______________________________

____

Which is the anterior end? ____

____

Add a little carmine (a harmless dye) under the edge of the cover slip. What causes the carmine particles to be agitated? ____

____

What do the paramecia feed on? How do they secure food? ______________________

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____

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What response do the animals make to a slight pressure on the cover slip? __________

____

Add a drop of ink at the edge of the cover slip. The paramecium will react to this irritation by discharging some of the trichocysts.

List all of the structures present in paramecium and absent in ameba. ______________

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L 35. HYDRA

Materials

Preserved or mounted and stained hydra, cross-section of hydra, microscope.

Observations

Examine an entire hydra under low power.

(1) SHAPE. Compare to a sac.

(2) MOUTH. Where is it located? ____________________

(3) TENTACLES. Long, slender arm-like structures. Where are they located? ____________________

____

How many are there? ____________________

(4) BODY WALL. Encloses the digestive cavity, the enteron.

(5) NEMATOCYSTS. These prominent cells with needle-like projections are found in the outer wall. They are especially numerous on the tentacles. What is their function?

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Examine the cross-section under low and high power. Notice that the animal is round in cross-section. Observe the structure of the wall.

(1) ECTODERM. This is the outermost layer of the wall. It is made up of large EPITHELIO-MUSCULAR CELLS, and scattered between them small INTERSTITIAL CELLS. The latter give rise to new epithelial-muscular cells, to nerve cells, to nematocysts, or to reproductive cells.

(2) ENDODERM. This is the inner layer of cells. It consists of muscle cells, gland cells, and interstitial cells. Some cells contain large vacuoles.

(3) MESOGLEA. This is a cement-like substance between the two layers.

(4) ENTERON. This is the digestive cavity.

Draw: (1) An entire hydra as seen under low power. Label.
(2) A cross-section showing cell detail accurately. Label.

How does the hydra obtain food? ____________________

____

How is the food digested? ____________________

____

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THE EARTHWORM

L 36. EXTERNAL FEATURES

Materials

Preserved earthworm, hand lens, dissecting tray, pins, scissors, forceps, dissecting needle, slide with cross-section of earthworm, microscope.

Observations

Rinse the earthworm in water, then put it into tray.

1. The animal is made up of SEGMENTS. The anterior knob-shaped structure, the PROSTOMIUM, is not considered a segment. The first segment follows it. How many segments are there in your worm?........................ Segments 31 to 37 are enlarged to form the CLITELLUM. It secretes the mucous EGG CAPSULE.

2. Run your finger along the ventral surface of the worm. The bristle-like structures that you feel are the SETAE. How many are there on each segment? .... Try to see them with the hand lens. What is their arrangement? ....

....

....

3. There are several openings in the worm. Locate (a) the MOUTH between the prostomium and the first segment; (b) a pair of openings of the SPERM DUCTS in segment 15; (c) a pair of openings of the OVIDUCTS in segment 14. There is also a pair of NEPHRIDIOPORES in each segment but these are too small to be seen with the hand lens. There are also tiny openings into the sperm receptacles in the grooves between segments 9 and 10, and between 10 and 11.

To what PHYLUM does the earthworm belong? What characteristics distinguish animals of this phylum from other animals? ....

....

....

....

....

EARTHWORM: INTERNAL ANATOMY

Put the specimen in the tray DORSAL side uppermost. Pin it down with a pin through the prostomium and one through the last segment. Do not stretch it too much. With the scissors, starting at the anterior end, make a longitudinal cut through the body wall along the median line. Do not cut into the organs below. Spread the cut edges carefully and notice the SEPTA (thin partitions) that join the body wall to the digestive tract. Cut these with a dissecting needle and pin the wall back with pins on each side about an inch apart.

L 37. THE DIGESTIVE SYSTEM

Observe the following:

(1) PHARYNX—A muscular structure in segments 1 to 5.

(2) ESOPHAGUS—A thin-walled tube in segments 6 to 13.

(3) CROP—A thin-walled enlargement in segments 14 to 16.

(4) GIZZARD—A thick-walled enlargement in segments 17 to 19.

(5) INTESTINE—A dark, thin-walled straight tube through the remainder of the segments to the ANUS.

What is the function of each of these divisions of the digestive tract? ....

....

....

....

....

....

....

What is the food of the earthworm? ....

L 38. THE CIRCULATORY SYSTEM

Observe the following:

(1) DORSAL BLOOD VESSEL—This runs along the median line of the digestive tract. It receives branches from the wall of the intestine and carries the blood forward.

(2) PSEUDOHEARTS—Five pairs of branches of the dorsal blood vessel which encircle the esophagus in segments 7, 8, 9, 10 and 11.

(3) VENTRAL BLOOD VESSEL—This runs along the median ventral line of the digestive tract. The hearts empty into it, and it gives off branches to the wall of the intestine.

(4) SUBNEURAL BLOOD VESSEL—A fine blood vessel running along the median ventral side of the nerve cord. It may be seen by lifting the whitish nerve cord below the intestine.

L 39. THE REPRODUCTIVE SYSTEM

(Reproduction in various organisms is dealt with in a later section of this book. The structures of the reproductive systems of the animals dissected will be dealt with in this section to save opening another specimen.)

(1) SEMINAL RECEPTACLES—Two pairs of small, white, sac-like structures against the ventral wall in segments 9 and 10.

(2) SEMINAL VESICLES—Two pairs of large, white, three-lobed sacs extending from segments 9 to 13.

(3) TESTES—Two pairs of tiny white organs inside the vesicles in segments 10 and 11. They are too small to be readily seen. The sperm ducts carry sperm from the testes through the pores in segment 15.

(4) OVARIES—One pair of tiny white organs in segment 13. The oviducts carry ova from them through the pores in segment 14.

L 40. THE EXCRETORY SYSTEM

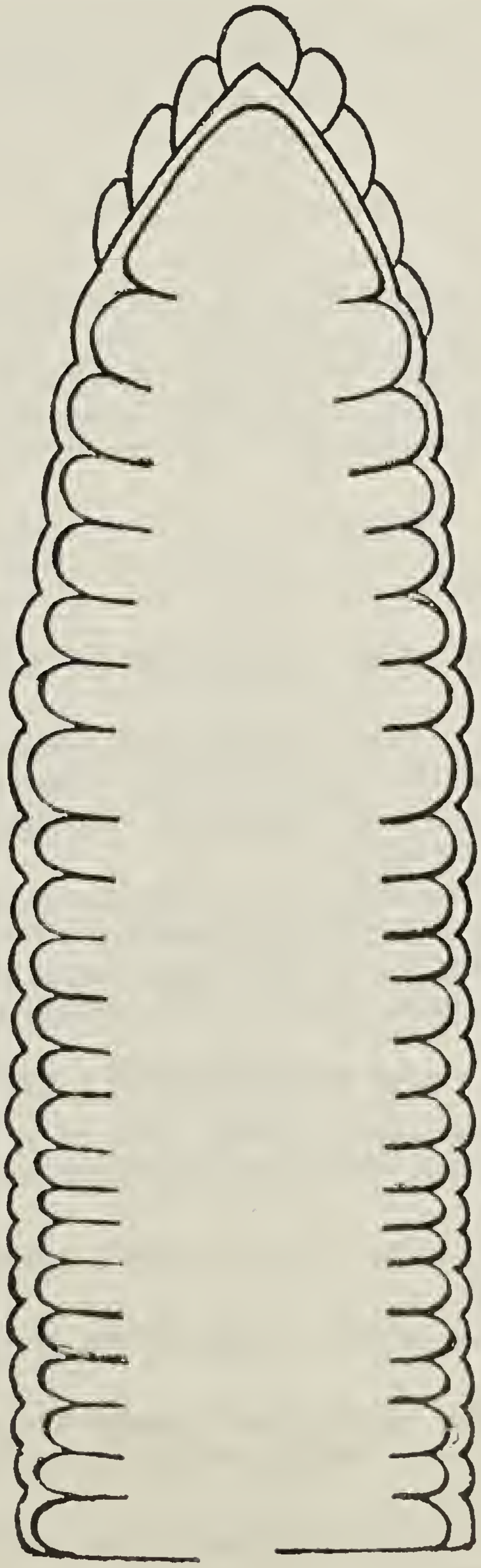
There is a pair of tiny NEPHRIDIAL TUBULES in each segment except those at the ends of the body. They can be seen with the hand lens as glistening, thread-like, coiled tubes with one end (the nephrostome) opening in the body cavity in the segment in front, and the other end opening in the body wall (the nephridiopore). Try to remove one with the forceps and examine it under low power of the microscope.

Notice that the earthworm has a true body cavity, the COELOM, between the body wall and the digestive tract, in addition to the digestive cavity or ENTERON. It also has muscle tissue which originated from the third body layer, the MESODERM, in both the body wall and the intestinal wall.

Return your worm to your specimen bottle for later use in connection with the nervous system.

L 41. EATHWORM: DRAWING FROM DISSECTION

On this outline of the earthworm show the systems observed in dorsal view. Number the segments and be careful to show each structure in the correct segment, and in scale. Make your lines bold and definite. Label fully.



Make a drawing of the earthworm as seen in side view with the wall nearest you removed to expose the internal organs. Number the segments and be careful to show all structures in the correct segments and in scale. Label fully.

L 42. EARTHWORM: DRAWINGS OF CROSS SECTIONS

Study the slide of a cross-section of the earthworm. Identify: skin, circular muscle, longitudinal muscle, coelom, enteron, typhlosole, endoderm, nephridium, setae, nerve cord, dorsal blood vessel, ventral blood vessel, subneural blood vessel.

From what segment might this section have been taken? --

Draw the section and label the structures listed above.

Construct a diagram similar to the one above showing the structures that would be seen in a cross-section through segment 9. Label fully.

Construct another diagram of cross-section through segment 13. Be sure to show all of the structures present in this segment and not in the others. Label fully.

GRASSHOPPER

L 43. EXTERNAL FEATURES

Materials

A preserved lubber grasshopper, dissecting tray, scissors, pins, forceps, hand lens.

Observations

Notice that the body of the grasshopper consists of three regions, the head, the thorax, and the abdomen.

1. HEAD. Observe one pair of ANTENNAE, one pair of COMPOUND EYES, three OCELLI or simple eyes (one above each antenna and the third between them), the upper lip or LABRUM, one pair of MANDIBLES, one pair of MAXILLAE, and a lower lip or LABIUM.

Slice a section off the compound eye and examine it under low power. It is made up of a large number of six-sided facets.

Hold the insect's head firmly in your left hand. Place one prong of the forceps under the labrum and with a pull and upward twist extract it. Do the same with each mandible, then each maxilla, and the labium. Arrange these parts on a piece of paper in the relative positions they were in the insect. Draw the mouth parts so arranged and label each.

Compare the mouth parts of a mosquito with those of the grasshopper. ____________________

____

____

____

2. THORAX. The thorax is made up of three segments: the prothorax, the mesothorax, and the metathorax. Each segment bears a pair of legs. The mesothorax and the metathorax each bear a pair of wings. Notice the veins in the wings and the manner in which they fold. Each leg consists of a COXA and TROCHANTER, a long FEMUR, a long spurred TIBIA, and a TARSUS. Label these in a metathoracic leg in the diagram.

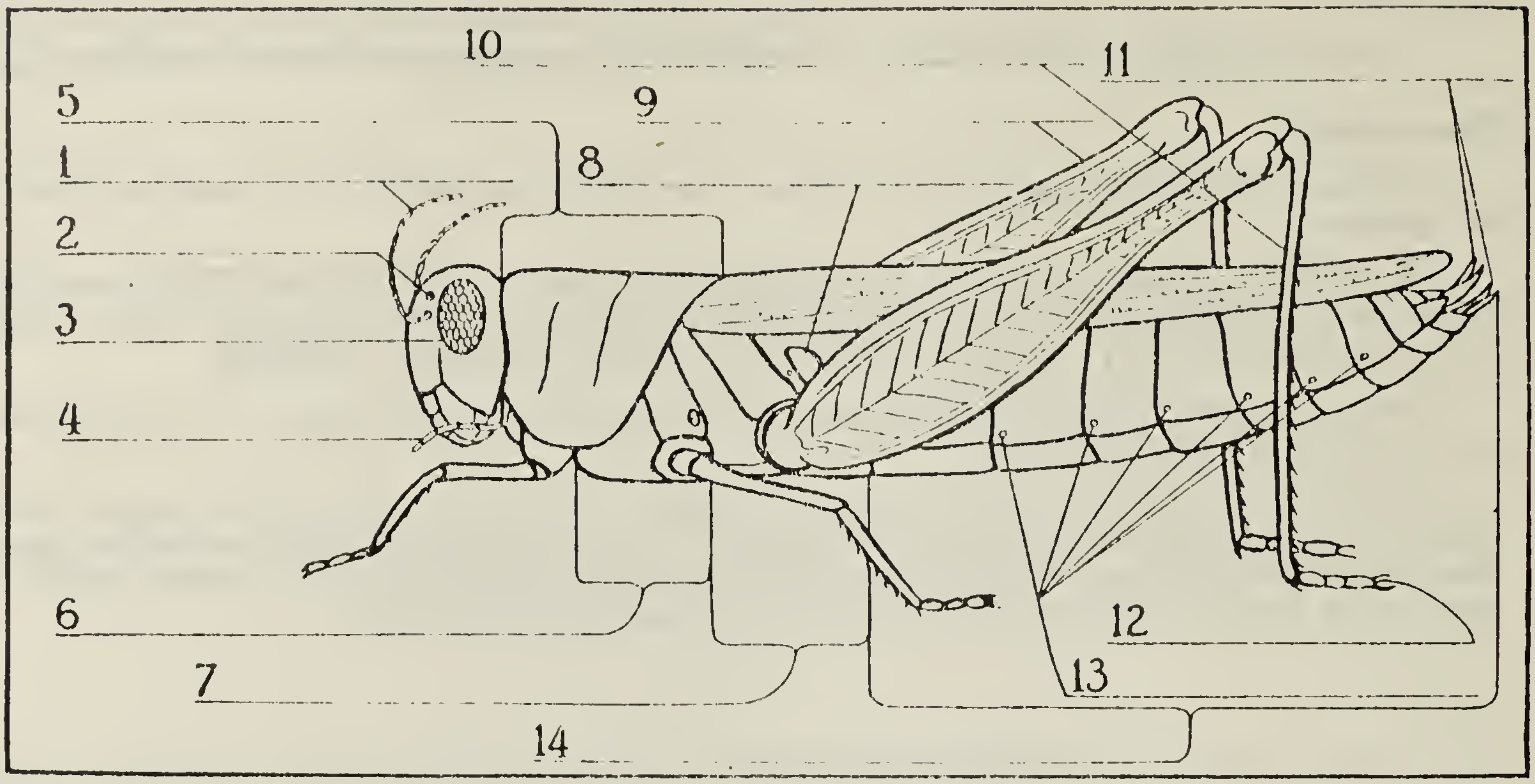
3. ABDOMEN. The abdomen is made up of eleven segments, but the plates of some of the posterior ones are partially fused. At the end of the abdomen is the external reproductive organ, in the female called the OVIPOSITOR. It consists of four prongs.

What is the function of the ovipositor? ____________________________________

____

Locate the TYMPANIC MEMBRANE or eardrum in the first segment, partly covered by the wings. Along the mid-line on each side are the SPIRACLES. Examine them with the hand lens.

Label all of the parts numbered on this diagram of the grasshopper.



L 44. INTERNAL STRUCTURE

Place the grasshopper in the tray and with the scissors make a cut from the posterior end of the abdomen to the back of the head along the mid-dorsal line. Carefully spread the cut edges and observe the internal structures.

1. THE CIRCULATORY SYSTEM. This consists of a single small dorsal tube just inside the dorsal wall. It contains valves. It pulsates to force the blood forward. The blood flows out the anterior end of this tube and back between the organs.

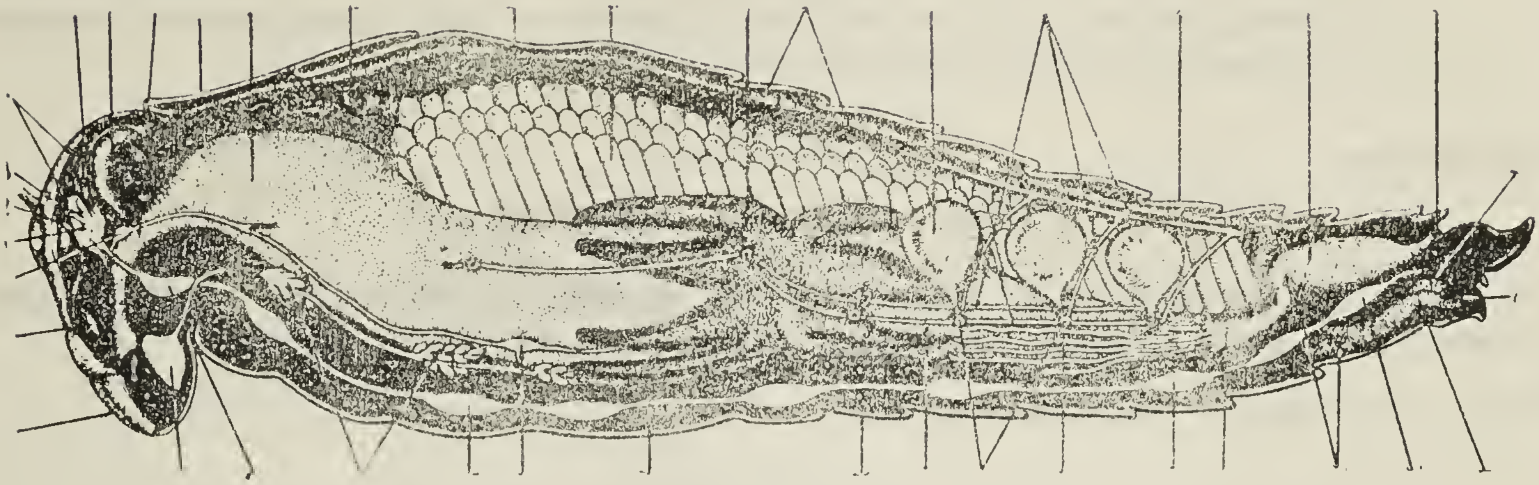
2. THE REPRODUCTIVE SYSTEM. If your specimen is a female the body cavity will probably be packed with hundreds of large eggs contained in a membranous ovary. The eggs are fertilized as they pass down the oviduct which ends between the prongs of the ovipositor.

3. THE RESPIRATORY SYSTEM. There are TRACHEAE leading from the spiracles to all parts of the body. The largest tracheae are trunk tubes running lengthwise near the spiracles. You may be able to see them as glistening threads with the hand lens. There is no hemoglobin in the grasshopper. Oxygen diffuses directly from the tracheae to the cells.

4. THE DIGESTIVE SYSTEM. Remove the eggs and observe the digestive system. It consists of an ESOPHAGUS, a very large CROP, eight large pouches or GASTRIC CAECA, a GUT, and a RECTUM.

5. THE EXCRETORY SYSTEM. This consists of a large number of MALPIGHIAN TUBULES which remove metabolic wastes from the body cavity and pass it into the rectum. They may be seen with the hand lens as a mass of tangled threads.

Label the parts mentioned above on this diagram of the internal organs of a grasshopper.



To what phylum does the grasshopper belong? ______

What characteristics distinguish the animals of this phylum from other animals? ______

To what CLASS does the grasshopper belong? ______

What characteristics distinguish animals of this class from the other classes of the phylum?

To what ORDER does the grasshopper belong? ______

What are the characteristics of this order? ______

What structural adaptations make insects such a successful group? ______

Return the grasshopper to your specimen bottle for later use.

THE FROG

Materials

A preserved frog, dissecting tray, scissors, dissecting needle, forceps, pins, hand lens.

Note: Each time the specimen is removed from the preserving bottle it should be rinsed with water to remove the excess formaldehyde. The smell of formaldehyde on the hands can be reduced by thoroughly soaping the hands before starting work and allowing the soap to dry on the hands. When you finish work wash the hands and the smell will wash off with the soap.

Observations

L 45. EXTERNAL FEATURES

Place your specimen in the tray, dorsal side uppermost. Observe the HEAD, TRUNK, APPENDAGES, EYES, EYELIDS, TYMPANIC MEMBRANE, NOSTRILS, MOUTH.

What is the nature of the body covering?

Has the frog a neck?

Notice the eyelids and the extra eye-covering, the NICTITATING MEMBRANE. What is the function of the latter?

The eye projects from the top of the head, but can be withdrawn. What advantage has this position of the eye?

What advantage is gained by having the nostril at the tip of the head?

How many toes are there on the forelegs?

How many on the hind legs? How is the frog adapted for swimming?

How does the frog move on land?

L 46. MOUTH

Cut the muscles at the angles of the mouth, then open the mouth cavity wide. Observe the UPPER LIP, the LOWER LIP, the MAXILLARY TEETH on the upper jaw, the TONGUE and the ESOPHAGUS, the GLOTTIS, EUSTACHIAN TUBES, the NOSTRILS, and the VOMERINE TEETH in two groups at the roof of the mouth. Probe a nostril with a blunt needle. Notice the flap forming a valve on the inside. Probe a Eustachian tube to show that it leads to the middle ear. The glottis is a vertical slip just behind the tongue leading into the trachea. Probe it with the closed forceps, then insert a blow pipe into the opening and see if you can inflate the lungs.

Draw the mouth cavity as seen with the mouth wide open. Carefully label all of the structures mentioned above.

L 47. THE DIGESTIVE SYSTEM

Note: BEFORE PROCEEDING WITH A DISSECTION, CAREFULLY READ THE INSTRUCTIONS. DO NOT CUT OR REMOVE ANY PART UNLESS SPECIFICALLY TOLD TO DO SO.

Place the specimen on its back in the tray and pin it down with a pin through each foot.

Lift the skin on the abdomen with the forceps and beginning between the hind legs cut the skin with the scissors along the mid-line to the tip of the jaw. Observe the LYMPH CAVITY between the skin and the muscle. Make a transverse cut in the skin on each side between the front and hind legs and pin the flaps back. Notice the large number of blood vessels in the skin. Much of the aeration of the blood takes place in the skin.

Lift the body wall with the forceps and make a longitudinal cut with the scissors, a little to one side of the mid-line, from the hind legs to the shoulder girdle. Note the ABDOMINAL VEIN attached to the inside of the muscles along the mid-line. Insert a dissecting needle between it and the muscle and free it from the muscle throughout its entire length. Do not break it. Now make a transverse cut in the wall at each side as you did with the skin and pin the corners back.

Most of the digestive system is now exposed to view. If your specimen is a mature female taken in the spring the body cavity will be filled with ovaries distended with speckled masses of eggs which crowd all the other organs forward. These eggs will have to be removed before you can proceed. Observe:

(1) LIVER, a large reddish brown organ made up of three lobes at the anterior end of the cavity.

(2) STOMACH, usually under the left lobe of the liver. Carefully lift the liver to see it.

(3) DUODENUM, the first part of the small intestine curving forward from the stomach.

(4) PANCREAS, a thin, irregularly shaped, white or yellowish body between the stomach and the duodenum.

(5) GALL BLADDER, a small greenish sac between the lobes of the liver. You will have to lift the right lobe of the liver to see it. The BILE DUCT connects the gall bladder to the liver and the duodenum.

(6) ILEUM, the main part of the small intestine from the duodenum to the rectum. It is coiled back and forth in the cavity.

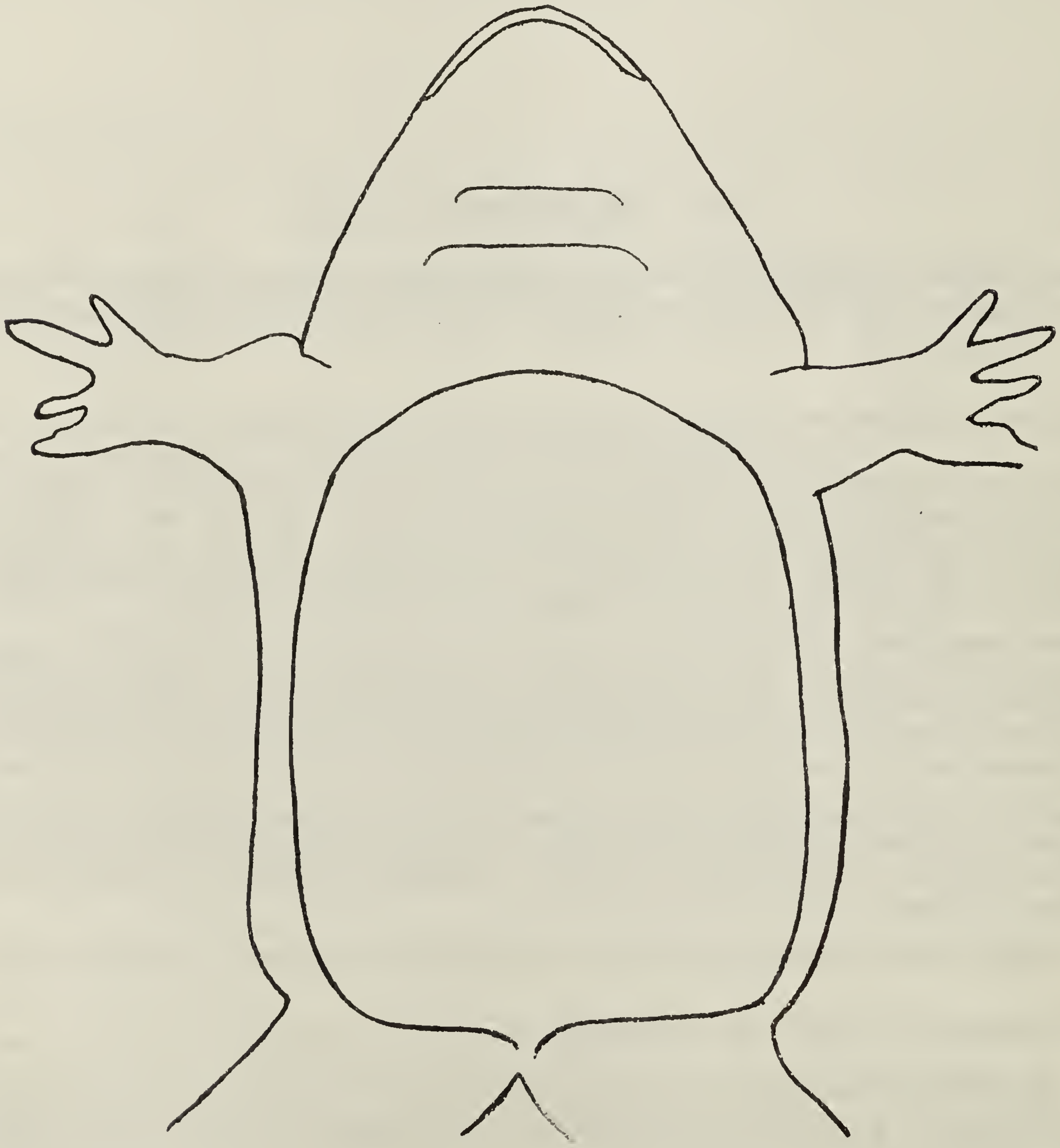
(7) RECTUM, the large intestine, from the posterior end of the ileum to the cloaca.

(8) CLOACA, the extension of the rectum to the ANUS. It receives posteriorly the ducts from the kidneys, and anteriorly the URINARY BLADDER.

(9) MESENTERY, the thin membrane which suspends the entire alimentary canal from the dorsal wall.

The tip of the heart can be seen between the lobes of the liver. Most of it is probably under the pectoral (shoulder) girdle.

Draw the digestive system, the urinary bladder, the heart and the mesentery as you see them in this view. Make your lines bold and clear. Label fully.



L 48. DIGESTIVE AND RESPIRATORY SYSTEMS (Extended)

(Leave this space for drawing to be done after you have completed the work on the heart).

L 49. THE VENOUS SYSTEM

Carefully insert one arm of the scissors under the breast bone and cut it along the mid-line. Spread the cut ends slightly apart to expose the heart and the main blood vessels. Remove the skin from the right hind leg and spread the muscles along the outer edge of the thigh to expose the FEMORAL VEIN. Follow this forward to where it forks. One branch, the RENAL PORTAL VEIN, comes from the kidney; the other branch, the PELVIC VEIN, joins its mate from the other leg to form the ABDOMINAL VEIN. Follow the abdominal vein forward to see where it enters the liver.

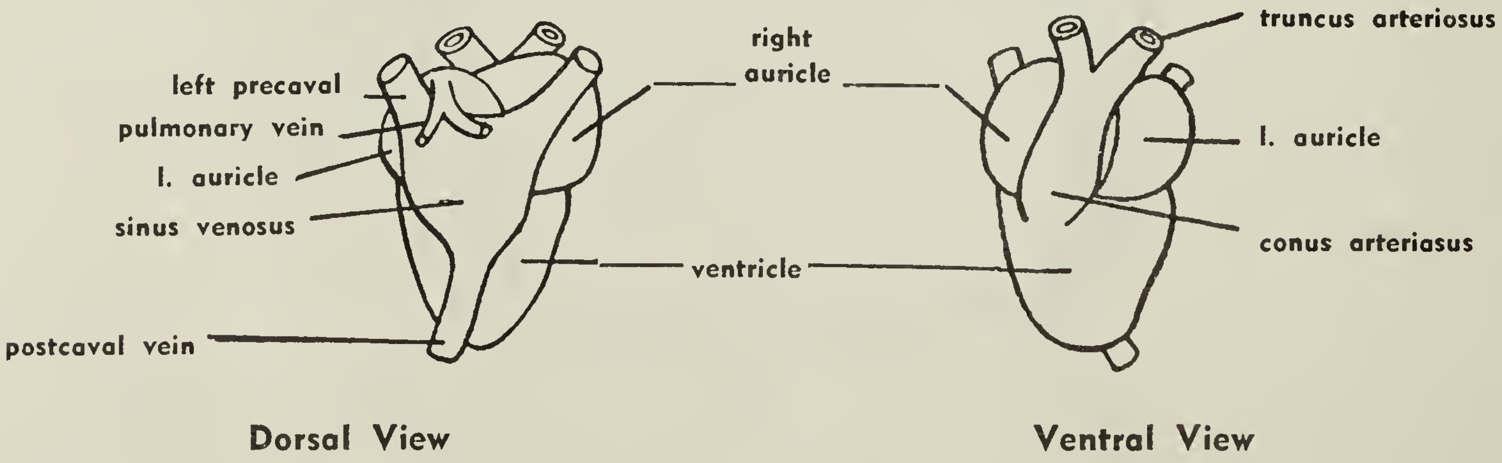
Make a drawing to show the inter-relationship of these veins.

Move the organs of digestion from the frog's right to the left. Observe the pair of large flat reddish or brownish KIDNEYS against the dorsal wall. Five or six RENAL VEINS from each kidney join between the kidneys to form the POST CAVA VEIN, a large vessel that carries blood from the kidneys to the heart.

Draw the kidneys, the renal veins, and the post cava vein.

L 50. THE HEART

The HEART is enclosed in a thin membranous sac, the PERICARDIUM. Remove the pericardium with a needle and make out the light colored, triangular-shaped, muscular VENTRICLE, and anterior to it the dark brown, thin-walled right and left AURICLES. Lift the tip of the ventricle and tilt it forward. Note the large POST CAVA vein that passes through the liver where it is joined by two HEPATIC VEINS then enlarges above the heart to form the thin-walled SINUS VENOSUS. A right and a left PRECAVAL VEIN bringing blood from the head and shoulder regions join the sinus venosus from the front. Blood from the sinus venosus empties into the RIGHT AURICLE. Small PULMONARY VEINS from the lungs empty into the LEFT AURICLE. They are difficult to see.



Make a large drawing of the heart and the venous system of the frog as seen from the ventral side. Label fully.

Where does the frog's blood go from the auricles? --

L 51. THE ARTERIAL SYSTEM

Observe the large artery that arises from the anterior right corner of the ventricle and passes forward over the right auricle. This is the CONUS ARTERIOSUS. It divides into a right and a left TRUNCUS ARTERIOSUS.

With needle and forceps carefully remove fat and other tissue that covers the trunci. Note that each truncus divides into three arteries:

(1) The CAROTID, which goes forward to the head region;

(2) The SYSTEMIC, the middle one, which goes towards the foreleg, then back under the digestive organs to join the one from the other side to form the DORSAL AORTA. Lift the digestive organs to one side to see it.

(3) The PULMO-CUTANEOUS, which carries blood to the lungs and the skin.

Follow the dorsal aorta back to see that it divides into a right and a left ILIAC ARTERY which go into the hind legs. (This is best seen after the digestive tract is removed.)

Note several RENAL ARTERIES that branch off from the dorsal aorta into each kidney, and a large COELIACO-MESENTERIC artery that branches off to the digestive organs near where the two systemic arches join.

Remove the heart and cut it horizontally with the scissors. Wash it out and study its structure.

Why is the wall of the ventricle so muscular? ....

....

....

Which direction does the blood move through an artery? ....

....

Which direction does the blood move through a vein? ....

....

Compare the heart of a frog to that of (a) a fish, (b) a man. ....

....

....

....

....

....

Make a large scale drawing of the heart and the arterial system of the frog as seen in ventral view. Label fully.

L 52. FROG: DRAWING OF CIRCULATORY SYSTEM

Combine the venous and arterial systems in one large drawing. Color the arteries red and the veins blue. Label fully.

DIGESTIVE SYSTEM (Continued) AND RESPIRATORY SYSTEM

Lift up the liver with the forceps and with the scissors free its anterior border from the tissues beneath it, being careful not to damage the lungs. Find the esophagus. Lift it up with the forceps and with the scissors cut across the floor of the mouth in front of the lungs so as to free the forward end of the esophagus. Lift and bend back the forward end of the digestive tract with the lungs. Carefully cut the stomach and liver loose from the tissues below, being careful not to damage the organs at the back. Cut the mesentery attached to the intestine and lift the whole digestive tract from the body except at its hinder end. Be careful not to disturb the kidneys. Cut the mesentery holding the loops in the ileum but NOT the one in the duodenum. Extend the digestive tract in a line. The liver and lungs should still be attached at the front.

In the space you left on page 71 (L 48) draw the digestive tract and the respiratory system in this position.

L 53. RESPIRATORY SYSTEM

Slit the stomach and a lung and observe the inner surface of each. What is the purpose

of the structures seen in the lung? --

Why is the skin of the frog so well supplied with blood vessels? ------------------------

----

Draw a small section of the lung. Show the SEPTA (ridges), and the ALVEOLI (sac-like depressions).

If a live frog or goldfish or other small fish is available, the circulation of the blood from arteries to veins through the tiny capillaries can be observed as follows:

Carefully wrap the specimen in muslin saturated with cold water except for the part to be examined. If the specimen is not too large it can now be placed in a petri dish with a little water in the bottom. Flatten out the caudal fin (tail) or the hind foot and observe under low power the blood vessels in the thin tail or the web of the foot. Do not keep a fish out of the tank for more than five minutes. It may be necessary to put a glass slide over the part being examined.

L 54. THE URINOGENITAL SYSTEM

The urinary and reproductive systems are closely associated in the frog and will be studied together. Observe:

(1) The KIDNEYS, a pair of large, flattened brownish organs close to the dorsal wall in the posterior part of the body cavity.

(2) The URETERS, a fine whitish duct running from the outer border of each kidney to the dorsal wall of the cloaca.

(3) The URINARY BLADDER, a large bi-lobed sac at the posterior end of the body cavity springing from the ventral wall of the cloaca. In most higher animals the ureters connect directly with the bladder.

(4) The ADRENAL BODIES, an irregular yellowish line on the ventral surface of each kidney.

(5) FAT BODIES, yellow, branching masses at the anterior end of each kidney.

(6) The TESTES, in the male, two yellow ovoid bodies lying against the ventral surface of the kidneys. There are very fine tubes leading from them into the kidney through which the sperm pass into the ureters and down to the cloaca.

The OVARIES, in the female. If your specimen is a mature female these were distended with eggs and were removed earlier. Otherwise they appear as a pair of dark grey folded bodies lying against the ventral wall of the kidneys.

(7) The OVIDUCTS, large, white, thick-walled tubes lying against the dorsal body wall in the female. The anterior end opens into the body cavity near the heart and the posterior end opens into the dorsal side of the cloaca.

In the male there are VESTIGIAL OVIDUCTS which are small and non-functional.

The eggs escape from the ruptured ovaries into the body cavity, then pass down the oviducts to the cloaca. They are fertilized after they pass from the body.

Draw the urinogenital system of your specimen, male or female. Label fully.

L 55. THE SKELETAL SYSTEM

Time does not permit cleaning and thorough study of the skeletal system.

By seeing and feeling the backbone from the body cavity you can determine that it is made up of ten vertebrae, the posterior one greatly elongated (the UROSTYLE).

Remove the skin and muscle from one hind leg and observe:

(1) The FEMUR, the main bone of the thigh.
(2) The TIBIO-FIBULA, the fused bone of the shank.
(3) The TARSUS, two bones separated in the middle, but fused at the ends.
(4) The METATARSALS, five bones in the foot.
(5) The PHALANGES, the bones of the toes.

Draw the bones of the hind leg of the frog. Label them.

The frog's leg is called a PENTADACTYL (five-fingered) limb. Name some other animals that have pentadactyl limbs. ____

____

____

Describe the modifications the pentadactyl limb has undergone in:

(1) Whale ____

____

(2) Bat ____

____

(3) Horse ____

____

(4) Ostrich (fore and hind) ____

____

____

Keep the frog in your specimen bottle for later use in study of the nervous system. You need not keep the digestive organs.

L 56. FROG: CROSS-SECTION RECONSTRUCTION

To test your understanding of the structure of the frog from dissection, draw from memory a cross-section of the frog cut through the ventricle of the heart. Show in their relative position and size these structures: skin, body muscles, vertebra, lymph sinus, body cavity, lungs, esophagus, liver, aortic arches, ventricle, sinus venosus. After you have studied the nervous system add the nerve cord and the autonomic trunks. Show all structures clearly and definitely. Label fully.

Draw from memory a similar reconstruction of a cross-section through the kidneys. Show the skin, body muscle, lymph sinus, vertebra, body cavity, stomach, pancreas, duodenum, ileum, kidney, dorsal aorta, post caval vein, reproductive organ, abdominal vein. Later add the spinal cord and the autonomic trunks. Label fully.

L 57. FROG: LONGITUDINAL-SECTION RECONSTRUCTION

Draw a reconstruction of a vertical longitudinal section through the middle of the frog. Show all of the structures that would be cut through, keeping in mind the relative size and position. Label fully.

To what phylum does the frog belong? ______________________________

What are the characteristics of this phylum? ______________________________

____

____

____

To what class does the frog belong? ______________________________

What characteristics distinguish this class from the other classes of the phylum? ______________

____

____

HUMAN TISSUES

Review the structure of an animal cell and epithelial tissues (L 11).

L 58. MUSCLE

Material

A prepared slide with stained sections of three types of muscle, microscope.

Observations

Examine each type of muscle under low, then high power. Determine which is smooth, which is striated and which is cardiac and draw a small section of each to show the differences in structure and appearance.

Smooth Muscle	Striated Muscle	Cardiac Muscle
______________________	______________________	______________________
______________________	______________________	______________________

In the spaces above state where each is found and whether it is voluntary or involuntary.

L 59. BONE (Optional)

Materials

Prepared slide with section of bone, two chicken leg bones, graduate, 20% hydrochloric acid, two Bunsen burners, wire gauze, ring stand, microscope.

Procedure

Examine the prepared slide under low, then high power. Draw a small part of the section. Label.

Place one of the long bones in the graduate and cover with 20% HCl. Two days later remove the bone, rinse thoroughly in water and examine. Place the other bone on the gauze on the ring stand and heat from above and below until it stops smoking and steaming. Allow to cool, then examine. Try to bend both bones.

What part of the bone was removed by the acid?

What is its purpose?

What part was removed by burning?

What is its purpose?

L 60. BLOOD

Materials

Microscope, slides, cover slips, dissecting needle, flame, alcohol or iodine.

Procedure

Sterilize the surface of one of your fingers with alcohol or iodine. Sterilize the needle by passing it through a flame. Prick the finger with the needle and squeeze a drop of blood on to the slide, and again apply antiseptic to the finger. Smear the blood on the slide with the needle to form a thin film of it. Place the cover slip over the blood and examine the slide with low and then high power.

Observations

(1) What is the color of the liquid part of the blood? ____________________

____

(2) What is the shape of the red corpuscles? ____________________

____________ Why are they red? ____________________

Draw a side and edge view of three red corpuscles. Make each about half an inch in diameter.

(3) What is the shape of the white corpuscles? ____________________

____

Draw two on the same scales as the red ones above.

What other bodies are in the blood in the circulatory system? ____________________

____________ Why do you not see them on your slide? ____________________

____

What is the relative abundance of these three kinds of bodies in the blood? ____________

____

What is the function of each of the bodies? ____________________

____

____

____

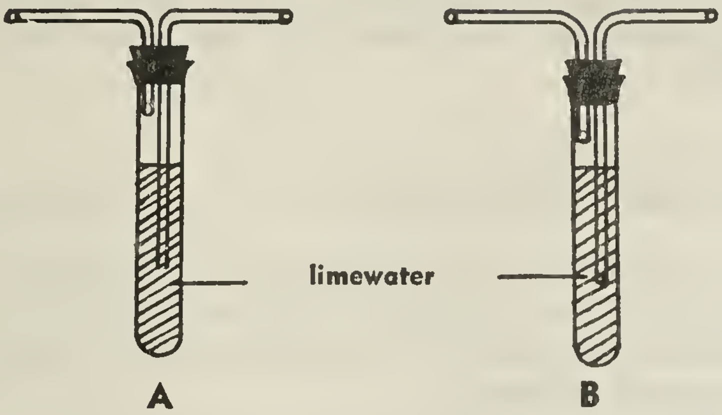
RESPIRATION

L 61. RESPIRATION IN MAN

Materials

Two large test tubes, 2-holed stoppers to fit test tubes, a long and a short elbow tube to fit each stopper, limewater.

Procedure and Observations



Arrange the apparatus as shown in the diagram. Inhale deeply three times through the short elbow tube in test tube A. Exhale deeply three times through the long elbow tube in test tube B.

Has any change occurred in the limewater in test tube A?

In test tube B?

What caused the change?

Where did it come from?

What other product is produced in this process?

Write a balanced chemical equation for respiration in a human

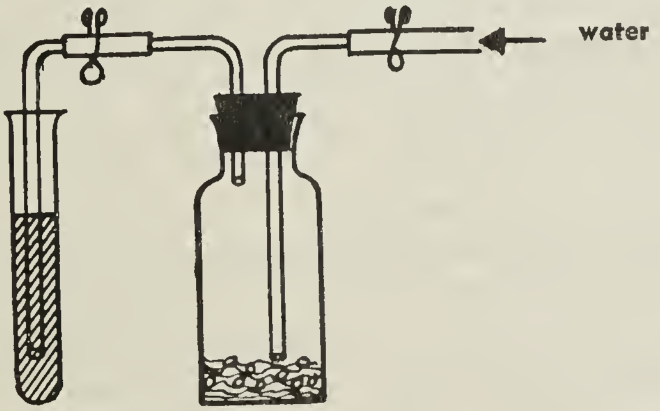
L 62. RESPIRATION IN GERMINATING SEEDS

Materials

Some wheat, bean or pea seeds, two wide mouthed bottles with 2-holed rubber stoppers to fit, elbow tubes, rubber tubing, pinch clamps, limewater, test tubes.

Procedure

Place some moist cotton batting in the bottom of each bottle. Add about 20 soaked seeds to bottle A. Attach elbow tubes, rubber tubes, and pinch clamps to stoppers and put stoppers tightly in bottles as shown in the diagram. Put the bottles in a warm, dark place for several days until seeds have germinated. Then put the end of the rubber tube that is attached to the short elbow tube in bottle A in a test tube of limewater, open pinch clamps, and pass water into the bottle through the tube attached to the long elbow tube. This will force the air from the bottle through the limewater. In a similar manner force an equal amount of air from bottle B through limewater in another test tube.



Observations

Conclusion

L 63. RESPIRATION IN PLANT ROOTS

Materials

A few germinated pea seeds, test tubes, cotton batting, water, beaker, phenalphthalien, limewater.

Procedure

Put some water in a beaker and add a few drops of phenolphthalien and enough limewater to turn the liquid red. Fill each of two test tubes to within about two centimeters of the top with this red liquid. Wrap a germinated pea seed with cotton batting, then place this in the open end of test tube A so that the root is in the liquid. Plug the top of test tube B with cotton batting. Leave both test tubes until next day.

Observation

What change has taken place in the color of the liquid in the test tubes? ______________________

____

____

(Carbon dioxide will combine with water to form a weak solution of carbonic acid. Phenolphthalien is red in a basic solution, colorless in an acid solution.)

Conclusion ____

____

Write a balanced chemical equation for the process of respiration in plants ____________________

____

How does the essential part of respiration in animals compare with that in plants? ______________

____

DISEASE

L 64. TYPES OF BACTERIA

Materials

Prepared stained slides of cocci, bacilli and spirilla, hay infusion, microscope.

Observations

(1) Examine prepared slides showing the three main types of bacteria under high power. Adjust the light carefully to get the best possible view. These, of course, are dead and stained bacteria.

Draw a bacterium of each type and describe its appearance. Below each name two diseases caused by bacteria of this type.

A Coccus	**A Bacillus**	**A Spirillum**
______________	______________	______________
______________	______________	______________
______________	______________	______________

(2) Examine a drop of hay infusion under high power. The light must be carefully adjusted in order to see unstained bacteria. Look for very large bacilli. Do any of them move?

What makes them move?

To what phylum do bacteria belong?

How do some bacteria survive unfavorable conditions?

L 65. CULTURE AND GROWTH OF BACTERIA

Materials

Beef extract or bouillon cubes, agar-agar or flake gelatin, peptone, balance, beaker, test tubes, sterile absorbent cotton, autoclave or pressure cooker, water, ten petri dishes, incubator.

Procedure

Measure out 100 ml. of water into a beaker. Add one-half gram of beef extract or bouillon cube and one gram of peptone. Mark the level of the contents.

Heat until the solids are dissolved.

Add one and one-half grams of agar-agar and boil until dissolved. Add water to replace any boiled away.

Add a few drops of sodium hydroxide to make the mixture slightly alkaline.

Pour the mixture into test tubes to a depth of about two inches, being careful not to get it on the sides of the tubes. (It would be better to filter the medium through cotton but this is difficult to do with classroom equipment.)

Roll cotton plugs and fit them into the tubes to a depth of about three-quarters of an inch.

Stand the test tubes in the autoclave or pressure cooker and heat under 15 pounds steam pressure for one-half hour. This temperature of 120° C or 248° F will kill all micro-organisms. Allow to cool to room temperature before opening the pressure cooker. Store in a cool, dry place.

Wash the petri dishes, then wrap them in groups of four in paper. Sterilize the wrapped dishes by heating in a dry oven for three hours at a temperature just hot enough to brown the paper but not char it. Store in a dry place until needed.

When ready to begin the experiment, stand 10 test tubes of the culture medium in a beaker of water and heat until the medium melts. Quickly singe the cotton plug of one tube in the flame, then seize the plug between the middle fingers, palm up, and carefully remove it from the test tube. Lift one edge of the cover of one of the sterilized petri dishes and pour the medium into the bottom of the dish. Allow it to flow so as to cover the bottom of the dish completely but not up onto the sides. Leave the dish in a cool place. Do the same with the other dishes. Number the dishes 1 to 10.

Remove the cover from plate No. 1, for ten minutes, then replace it.

With a clean, sterilized pipette place a drop of river or pond water on the surface of the medium in plate No. 2 and tip the dish so that it flows across the surface.

In a similar manner place a drop of raw milk on plate No. 3.

To plate No. 4 add a drop of boiled milk.

Lift the cover of plate No. 5 a little and gently touch the surface of the medium with the four finger tips.

Allow a fly to walk across the surface of the medium in plate No. 6, then remove the fly.

Place a coin on the surface of plate No. 7 for a minute or two.

Remove the cover from plate No. 8 and sneeze against the surface, then quickly replace the cover.

Do not open plates 9 and 10.

Leave all ten plates in the incubator at 37°C, or in a warm dark place for 48 hours, then examine.

Observations

In the outlines below make sketches to show extent and characteristics of the bacterial growth that appear. Indicate the colors of the colonies.

1 **Air**	**2** **Water**	**3** **Raw Milk**	**4** **Boiled Milk**	**5** **Fingers**
6 **Fly**	**7** **Coin**	**8** **Sneeze**	**9**	**10**

How did these colonies originate?

What is the purpose of plates No. 9 and No. 10?

Conclusion

How could a pure culture of one species of bacteria be obtained from one of these plates?

Plates prepared in this way may be used to test the effect of various antiseptics, and to determine the effect of temperature on bacterial growth, if time permits.

BEHAVIOR

L 66. TROPISMS IN PLANTS

Plant corn kernels and pea seeds in sawdust against the glass forming one wall of a box. Place the seeds with the radicles pointing in different directions. Leave the box in a warm, dark place until the root is between one and two inches long, then turn the box on end and leave for another few days, then turn upright and leave for another day or so.

Observe the direction of growth of the root and the shoot at each stage, and record your observations here:

What seems to be the stimulus causing the growth observed?

Which part of the plant made a positive response to this stimulus?

Which part made a negative response?

Plant oat grains in two pots. When the seedlings break through the soil place the one pot in a box blackened on the inside and having a vertical slit about three inches by one-half inch a little above the top of the pot. Leave the other in bright light. Compare the growth of the stems in the two pots after a few days.

What stimulus caused the difference in growth?

Describe an experiment that would demonstrate negative phototropism in roots

L 67. TROPISM IN ANIMALS (Optional)

Place a large drop of a vigorous Paramecium culture on a clean slide. Place the slide over a piece of dark paper. You should be able to see the Paramecia as tiny, moving white specks with the naked eye or with a hand lens.

1. When you have identified the Paramecia, add a drop of weak acetic acid to one edge of the culture on the slide. Do the Paramecia enter this area? ____________________

What is their reaction called? ____________________

2. Place a tiny bit of hay or wheat from an active infusion at one edge of a drop of Paramecium culture on another slide and observe for a few minutes. What type of response is this?

____

3. Take another slide with a drop of culture on it. Touch the wire connected to the plus terminal of a dry cell to one edge of the drop and a wire from the minus terminal to the opposite edge. Describe any response observed. ____________________

____

____

What type of response is this? ____________________

Make a drawing of the slide in each of the above cases showing the drop of culture and labelling the material added. Use dots to indicate the concentration of the Paramecia.

L 68. NERVOUS SYSTEM OF EARTHWORM

Take the earthworm previously used in connection with the digestive system from your specimen bottle and carefully remove some of the muscle tissue above the pharynx in segment 3. This will expose the BRAIN, a white bi-lobed structure above the pharynx. From each lobe of the brain a whitish cord passes down around the pharynx and these join below it to form the VENTRAL NERVE CORD. Push the digestive organs to one side and if necessary clear away some of the brownish muscle. Observe an enlargement of the nerve cord in each segment. These are GANGLIA. Three pairs of nerves branch from each ganglion. Of what does each nerve consist? --

----

Draw the nervous system of the earthworm as seen in dorsal view. Label fully.

L 69. NERVOUS SYSTEM OF GRASSHOPPER

Take the grasshopper previously used from your specimen bottle and cut off the alimentary canal at its forward end and remove the organs from the body. Observe:

(1) The NERVE CORD lying on the ventral wall of the body, partly concealed by fat. Notice that it is double.
(2) GANGLIA, five enlargements of the cord in the abdomen, and four in the thorax, with fine nerves radiating from each.
(3) NERVE CONNECTIVES from the anterior ganglion around either side of the esophagus.
(4) The BRAIN on top of the head between the eyes. Carefully cut away the exoskeleton to expose it. Notice the OPTIC LOBES, and the ones to the antennae.

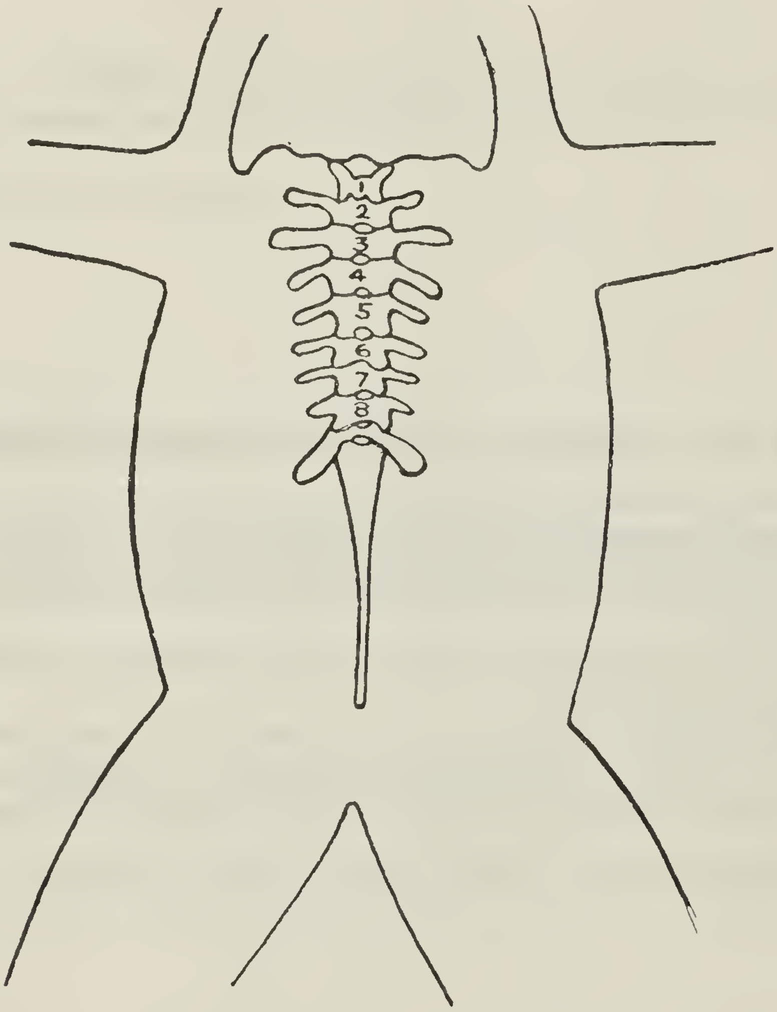
Make a large drawing of the nervous system of the grasshopper as seen in dorsal view. Label fully.

L 70. NERVOUS SYSTEM OF THE FROG

(1) Take the frog from your specimen bottle and remove the alimentary tract and the kidneys from the body cavity, if this has not been done previously. Locate the SPINAL NERVES, ten pairs of white strands issuing from between the vertebrae of the spinal column. The anterior one issues from between the skull and the first vertebra. It is very small. Number two is the largest. It issues from between vertebrae 1 and 2 and leads to the foreleg. Nerves numbers 8 and 9 are large and together with branches from nerves 7 and 10, fuse posteriorly into the SCIATIC NERVE, which supplies the hind leg.

Find the AUTONOMIC TRUNKS. These are two fine, silvery strands, running along the outer edges of the systemic arches and the dorsal aorta. Lift one of them gently with the needle and observe the fine threads that connect the trunk to each spinal nerve.

On this outline of the vertebral column, draw the ten spinal nerves, and the two autonomic trunks. Show them in correct relative size. Label and number the spinal nerves.



(2) Remove the skin along the middle of the back, then with the forceps remove the muscle so as to expose the vertebral column from the skull to the hump.

Bend the head down slightly. A dark membrane can be seen where the first vertebra meets the skull. Insert the tips of scissors in this opening and cut the bones at the top of the skull. Carefully insert one arm of the forceps under the bone and break away the bone. Repeat, working forward between the eyes until the entire brain is exposed. Now insert the forceps between the top of the vertebrae and the spinal cord and carefully break away the bone until the spinal cord is exposed back to the hump.

Raise the OPTIC LOBES and observe the OPTIC NERVES underneath. Trace them to the eyes. Notice the X-shaped OPTIC CHIASMA where part of the nerve from the right eye joins part of the one from the left eye and goes to the left optic lobe and vice versa.

Raise the spinal cord and observe where the spinal nerves join it. Each has a dorsal and a ventral root.

Draw a dorsal view of the brain and the spinal cord. Label:

(a) CEREBRAL HEMISPHERES—The largest division of the brain.

(b) OLFACTORY LOBES—Elongated, fused, in front of the cerebrum.

(c) OLFACTORY NERVES—From the olfactory lobes to the nostrils.

(d) DIENCEPHALON—Small transverse part, immediately behind the cerebral hemispheres.

(e) OPTIC LOBES—Two conspicuous round bodies behind the diencephalon.

(f) CEREBELLUM—A narrow transverse ridge behind the optic lobes.

(g) MEDULLA OBLONGATA—The hind part of the brain which narrows to form the spinal cord. Note the triangular hollow in it.

(h) SPINAL CORD.

(i) SPINAL NERVES—Ten pairs. Show the roots.

(3) Cut the cranial and spinal nerves as far from the brain and cord as possible. Carefully lift the brain and cord out and place it in your tray ventral side up.

Draw the brain in ventral view. Label all of the parts listed above that can be seen in this view.

REPRODUCTION

L 71. SPONTANEOUS GENERATION—REDI'S EXPERIMENT (Optional)

Materials

Three small bottles, raw meat, cellophane, cheesecloth.

Procedure

Place piece of meat in each bottle, A, B, and C.

Leave bottle A uncovered.

Cover bottle B with cellophane.

Cover bottle C with cheesecloth.

Place the three bottles on a window sill where flies are present. Examine them periodically for several weeks.

Observations ____________________

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Conclusion ____________________

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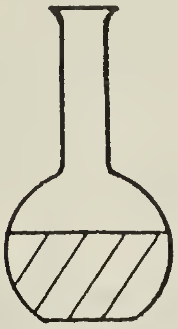
L 72. SPONTANEOUS GENERATION—PASTEUR'S EXPERIMENT (Optional)

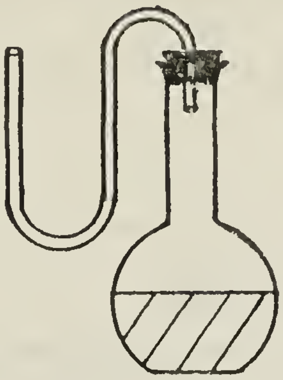
Materials

Two Florence flasks, 1-holed stopper, burner, S-shaped glass tube, 3.5 g. of beef extract, 10 g. peptone, 5 g. table salt, 10 ml. normal sodium hydroxide, 1 liter of water.

Procedure



A



B

Mix the water, beef extract, peptone, salt and sodium hydroxide together and pour into the flasks to fill them about three quarters full. Leave flask A unstoppered. Put the S tube through stopper in flask B. Boil both flasks for an hour over a low flame so as not to evaporate too much liquid. Place both flasks away and examine from day to day. At the end of the experiment examine a drop from each flask under high power.

Observation

Did the broth in either flask become cloudy? What does this indicate? Did air enter both flasks? Did dust enter?

Conclusion

L 73. PLEUROCOCCUS: A Single-celled Alga

Examine pleurococcus on a permanent slide or fresh material under low and high power of the microscope. Identify the cell WALL, CYTOPLASM, NUCLEUS, and CHLOROPLAST. Look for groups of two, four, or eight cells. Draw one of these groups on a scale large enough to show the parts listed above. Label

This is reproduction by fission. What type of reproduction is it?

Account for the groups of cells.

Examine any other single-celled algae available such as Closterium, Chlamydomonas, and Euglena. Draw one of each. Label the same parts as in the pleurococcus.

How do these plants reproduce? ____

L 74. DIATOMS

Examine diatoms on a permanent slide or in the ooze from the bottom of a pond under low and high power of the microscope. Each cell is enclosed in pillbox-like case of silica. Notice the characteristic shape and markings.

Draw one of each type observed. Label wall, nucleus, chloroplast.

How do diatoms reproduce? ____

L 75. SPIROGYRA: A Filamentous Alga

(1) Examine under the low power of the microscope some of the scum found floating on slow-moving, shallow streams or ponds. Notice that it is a tangled mass of green filaments. Each filament is made up of a series of similar cylindrical cells joined end to end. They are never branched. Each cell consists of:

(a) A CELL WALL surrounded by a gelatinous sheath.

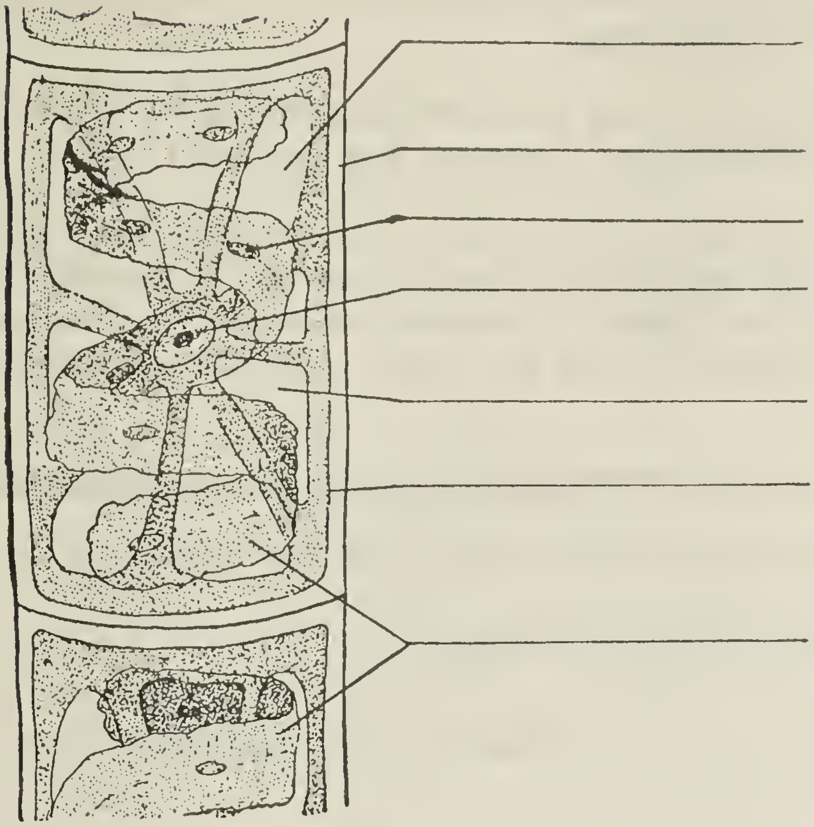
(b) CYTOPLASM, a thin dense layer close to the wall with strands extending to the center of the cell.

(c) CHLOROPLAST, a green ribbon-like structure, spiralling from one end of the cell to the other.

(d) PYRENOIDS, a row of round bodies in the center of the chloroplast, thought to be connected with starch formation.

(e) VACUOLE. This takes up most of the center of the cell, and contains a thin, watery sap.
(f) NUCLEUS, suspended in the cytoplasm near the center of the cell.

Name the parts indicated on this diagram:



How does the filament grow in length? ______________________________

____

____

(2) Examine a permanent slide of conjugating Spirogyra. Observe some filaments parallel to one another with CONJUGATION TUBES connecting them. Notice that in some cells in these filaments the protoplasm is rounded up in the center of the cell to form a GAMETE. Some cells are empty and the cell in the other filament connected to it contains a thick-walled ZYGOSPORE. Are the zygospores all in the same filament? If so, this is a female filament and the other a male filament, as the male gametes always do the moving.

To the right of the diagram above draw two conjugating filaments. Label fully.

L 76. YEAST

Drop a little dry yeast into a weak solution of molasses in a beaker and leave in a warm place for a few hours. Place a drop of the material on a slide, put a cover slip over it and examine under low power, then high power. Look for yeast cells that are budding.

Draw several cells in various stages. Label.

L 77. BLACK BREAD MOLD

Put a slice of stale white bread that has been exposed to the air in a petri dish and moisten it. Cover and leave in a warm, dark place for several days.

The fuzzy growth that appears on the bread is the body (MYCELIUM) of the mold; the tiny, dark, round spots are the spore cases (SPORANGIA). Examine with the hand lens.

With the forceps, place a small amount of the mold in a drop of water on a slide, add a cover slip, and examine under low power, then high power of the microscope Notice that the mycelium is made up of HYPHA (strands) of three kinds. (1) rhizoids, which go into the bread and secure nourishment, (2) stolons which spread out over the surface and (3) ascending or aerial hyphae.

On the top of each ascending hypha is a SPORANGIUM containing numerous tiny dark SPORES.

Draw a black bread mold plant and label the parts referred to.

What is the function of the spores?

What type of reproduction is this?

How did the mold get started on the piece of bread?

(2) Examine a permanent slide showing conjugating black bread mold, under low power of the microscope. The mycelium on this slide is of two kinds, + (plus) and — (minus).

Find two hyphae growing close together with branches growing out towards one another. In some there will be cells formed at the end of each of these branches (suspensors). These cells are GAMETES which combined to form a ZYGOTE. If the gametes cannot be distinguished in appearance, the process is called CONJUGATION. A + gamete will combine with a — gamete to form a zygote, but two + gametes will not combine, nor will two — gametes.

The zygote forms a thick, rough, dark wall around itself to form a ZYGOSPORE.

Draw + and — hyphae, showing stages in the formation of a zygospore.

What type of reproduction is this?

What purpose does the thick-walled zygospore serve?

When would you expect conjugation to occur in bread mold?

Examine any mushrooms, puff balls, or shelf fungi available. Compare their method of reproduction with that of bread mold.

L 78. BLACK STEM RUST OF WHEAT: A Parasitic Plant

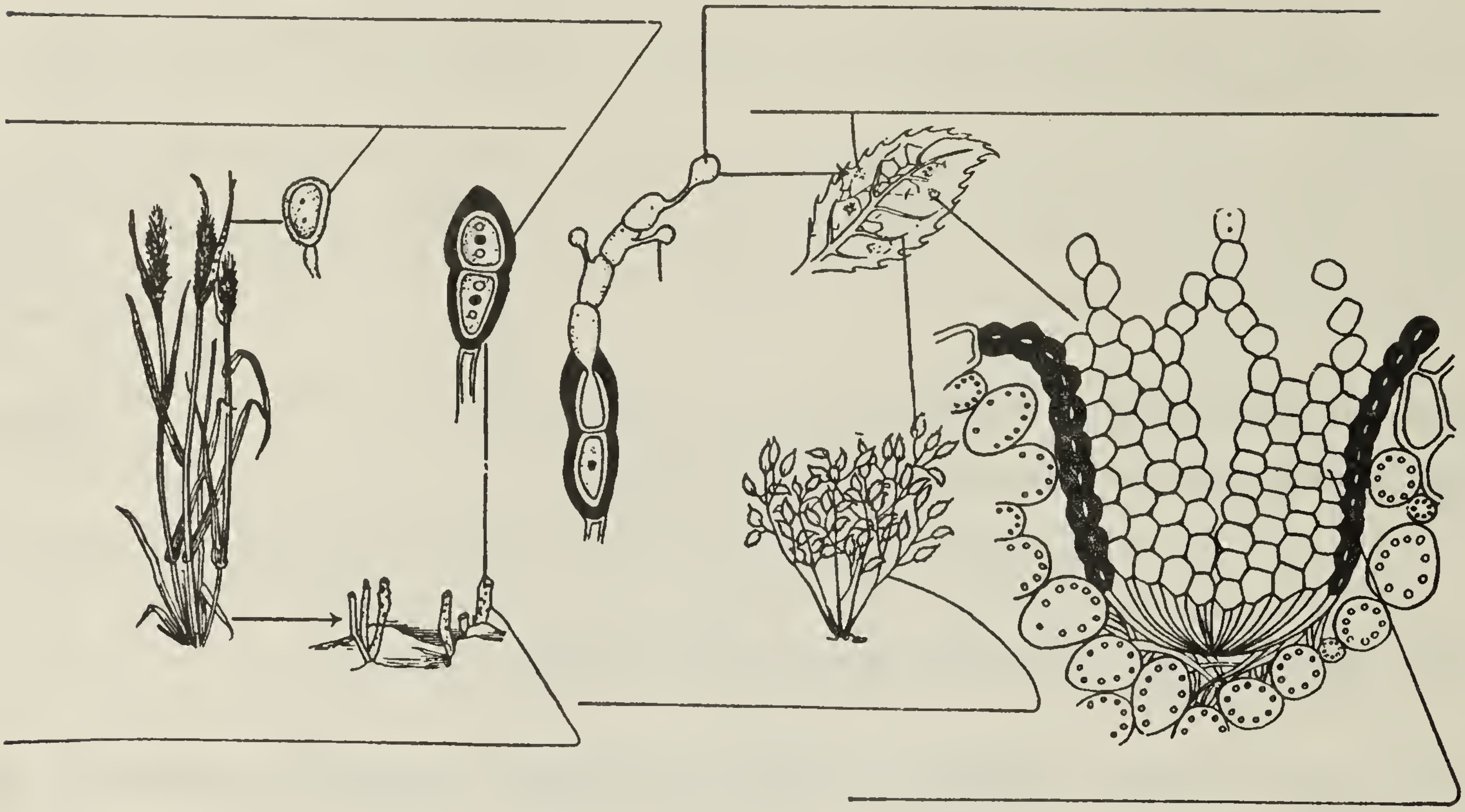
Examine under low and high power of the microscope a permanent slide of the life cycle of black stem rust of wheat. Also examine, if available, wheat stems infected with the fungus.

The mycelium grows inside the stem, taking nourishment from the stem tissues. During the summer the fungus breaks through the epidermis of the stem in brownish pustules and forms thin-walled, reddish-brown, one-celled, binucleated, oval UREDOSPORES. These spores are carried by wind to other wheat plants, germinate, and a hypha enters the plant and spreads inside the stem and produces uredospores in about ten days. Late in the season, in the same sori that produced the uredospores, elongated two-celled spores with thick walls and containing two nuclei are formed. These are TELIOSPORES. They remain on the straw or stubble all winter. In the spring each cell of a teliospore germinates a short hypha called a BASIDIUM and each basidium forms four small BASIDIOSPORES. The basidiospores cannot infect wheat but can grow only on the common barberry, where the mycelium spreads inside the leaf, and later breaks through the upper epidermis to form tiny single nucleated PYCNIDIOSPORES. These are either + or —. If an insect carries a spore to mycelium of the opposite kind, they fuse to form a new binucleated mycelium which grows down through the leaf and breaks through the lower epidermis in cup-like structures in which bright orange colored AECIDIOSPORES are formed. These cannot re-infect barberry but can grow only on wheat.

Identify as many as possible of these stages on the slide and on the stem of wheat.

Label the parts indicated on this diagram.

THE LIFE CYCLE OF WHEAT RUST



L 79. MOSS: A Bryophyte

Examine fresh or preserved specimens of moss plant. Observe that some have a rosette of leaves at the tip. These are MALE GAMETOPHYTES. Within the rosette are male organs, the ANTHERIDIA, which produce the SPERM CELLS. Other plants have the leaves loosely rolled together at the tip. These are FEMALE GAMETOPHYTES. Among these leaves are the female organs, the ARCHEGONIA, which produce the OVA (female gametes).

Draw a male and a female gametophyte. Label.

How is fertilization accomplished? ....

....

....

Why are mosses small plants that grow in moist places? ....

....

....

At the tip of some female gametophytes are stalked SPOROPHYTES which produce SPORES in the capsule at the top. Each spore germinates to form a filament called a PROTONEMA, from which the gametophytes arise.

Draw a female gametophyte with a sporophyte growing out of the top. Label.

Where does the sporophyte get its nourishment?

Describe ALTERNATION OF GENERATIONS in moss. The sporophyte is diploid. Meiosis occurs during spore formation. The gametophyte is haploid. Make clear how the number of chromosomes gets doubled again in the next sporophyte generation.

L 80. FERN: A Pteridophyte

Examine a growing or mounted specimen of a fern. This is the SPOROPHYTE. Look for brownish round bodies on the under surface of the leaves. Under these bodies are the SPORANGIA in which the SPORES are produced. Has the sporophyte a stem? Has it roots? Draw a sporophyte and label these parts.

Where would you look for a fern gametophyte?

How large is it?

Describe ALTERNATION OF GENERATIONS in the fern.

L 81. PINE: A Gymnosperm

In gymnosperms the reproductive structures are in cones. The cones are made up of modified leaves called SPOROPHYLLS which bear the male or female reproductive organs.

(1) Examine a permanent slide of a longitudinal section of a male cone.

Observe the SPOROPHYLLS with the POLLEN SACS on the lower surface containing numerous POLLEN GRAINS. Each pollen grain has two balloon-like outgrowths at the sides.

Draw part of the cone. Label the parts mentioned.

Draw one pollen grain.

How does pollination occur in gymnosperms?

What is the function of the balloon-like outgrowths on the pollen grains?

(2) Examine the slide of a female cone. Identify the SPOROPHYLLS and the OVULES. Draw a part of the cone to show these.

(3) Examine the cones of local gymnosperms collected in connection with Exercise L 4. Learn to identify them. Where are the seeds found? ____________

Are the seeds naked or enclosed? ____________

Do all gymnosperms shed their seeds at the end of the first season? ____________

____

How are the seeds disseminated? ____________

____

____

L 82. THE FLOWERING PLANTS (Angiosperms)

Examine a perfect flower such as a tulip, lily, gladiolus, or iris. Observe:

(1) The PEDICEL—The stalk of the flower.

(2) The RECEPTACLE—The tip of the pedicel bearing the other parts.

(3) The SEPALS—The outer leaf-life parts, collectively called CALYX.

(4) The PETALS—Inner leaf-like parts, collectively the COROLLA.

(5) The STAMENS—Each consists of a FILAMENT and an ANTHER, which contains POLLEN.

(6) The PISTIL—The center part made up of an enlarged base, the OVARY, an elongated part, the STYLE, and STIGMA at the top. The ovary contains OVULES, each of which may develop into a seed.

Make a neat, labelled drawing of (a) a stamen, (b) a pistil. Label all of the parts mentioned.

With a razor blade cut a cross section of the ovary and examine it with the hand lens. Draw the section and label the parts.

How many sepals were present? ____________ Petals? ____________

Stamens? ____________ Pistils? ____________

Examine any other flowers available and compare each with this one.

How can you distinguish flowers of monocotyledonous plants from those of dicotyledonous plants?

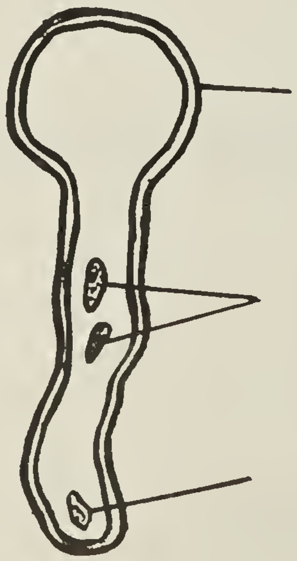
State three other characteristics that distinguish these two kinds of spermatophytes.

Examine a permanent cross-section of a lily flower bud. Identify the SEPALS, PETALS, STAMENS, and PISTIL. Notice the POLLEN GRAINS and the nuclei in them.

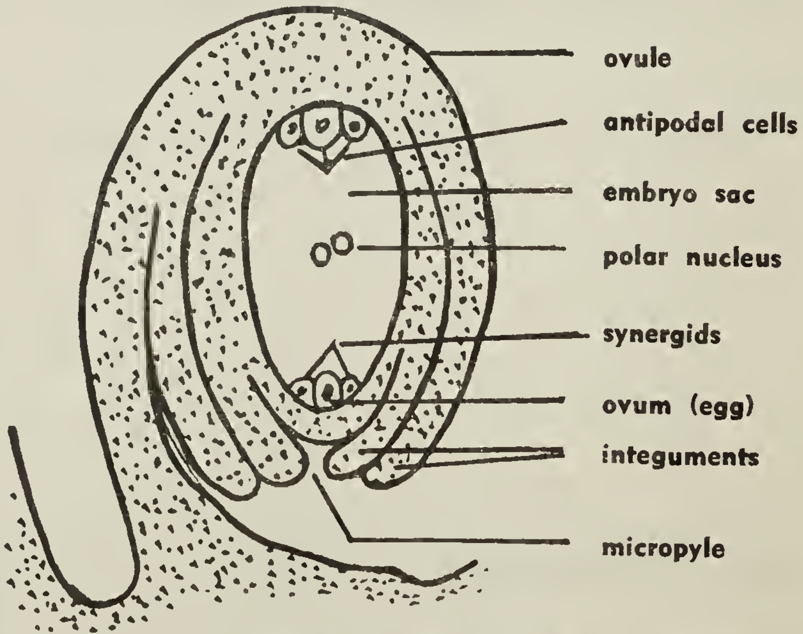
Draw the cross-section. Label the parts listed.

The pollen grain is a spore. It develops into the male gametophyte which produces the male gametes. Label the parts indicated on the diagram of a male gametophyte below.

A spore forms in the center of the ovule, enlarges to form the EMBRYO SAC inside which the FEMALE GAMETOPHYTE develops. The parts of this are labelled in the diagram below. It never consists of more than eight nuclei.



Male Gametophyte



Female Gametophyte

Examine a permanent cross-section of a lily ovary. There are usually six ovules in one plane. Pick out one and identify the parts shown in the diagram above. Draw this ovule and label the parts seen.

Put a drop of 10% sucrose solution on a slide and shake some pollen from an anther in it. Put a piece of wet blotter in the bottom of a petri dish. Place the slide on the blotter and cover it. Leave until next day, then examine the slide under low power. It may be stained with methylene blue or iodine. Draw one of the pollen tubes.

Where did the male gometophyte get nourishment? ____________________

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Where does it get nourishment in nature? ____________________

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Describe how fertilization takes place in the flower studied. ____________________

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What is meant by double fertilization in flowers of this type? ____________________

____

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Compare the male gametophyte of this plant with that of a moss.

Compare the female gametophyte of this plant with that of a moss.

Examine the flower of any grass available, and that of some tree such as poplar, birch or willow.

Draw a flower of each kind and label the parts.

L 83. THE FRUIT

Soak six bean or pea seeds and six corn kernels over night.

(1) Examine a bean seed with the hand lens. Notice the HILUM (scar) where the seed was attached to the placenta of the fruit, and the MICROPYLE (tiny opening) where the pollen tube entered the ovule to effect fertilization. Remove the seed coat and spread the two COTYLEDONS apart to see the EMBRYO between them consisting of a HYPOCOTYL (primitive stem and root) and a PLUMULE (a pair of primitive leaves).

Draw a seed as seen with seed coat on, and one with cotyledons spread apart. Label.

(2) Examine a corn kernel. The outer layer here is the dried ovary wall, not a seed coat. Notice the ENDOSPERM, the darker part farthest from the tip, and the embryo, the lighter part near the tip. With a razor blade, cut the kernel lengthwise through the embryo. identify the endosperm, cotyledon, plumule, and hypocotyl. Draw the kernel showing the cut surface. Label the parts.

(3) Place a cylinder made from a blotter inside each of two tumblers and moisten it thoroughly. Place six bean seeds between the blotter and the glass of one tumbler and corn kernels in the other. Put in a dark place for a few days. Keep the blotter moist. Observe the first signs of growth and make daily notes describing each stage of growth in each tumbler for the next ten

days. --

L 84. REPRODUCTION: PARAMECIUM

Examine a drop of paramecium culture (hay infusion) under low power. Look for ones in the process of dividing by fission. Draw one.

L 85. REPRODUCTION: HYDRA

Examine a slide of hydra, entire mount, under low power. Look for BUDS extending sideways from the parent. Is this sexual or asexual reproduction? ______________________

Draw a budding hydra.

How do hydra reproduce sexually? ______________________

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L 86. REPRODUCTION: EARTHWORM

Refer back to your work on dissection of the earthworm (L 39). Recall that each worm had both testes and ovaries. What is the term used to describe such an animal? ______________________

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Describe how fertilized eggs are produced in the earthworm. ______________________

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L 87. REPRODUCTION: INSECTS

(1) Review the reproductive system of the grasshopper (L 60). Examine a Riker mount of the metamorphosis of a grasshopper. Is this complete or incomplete metamorphosis?

What is meant by molting?

Why do insects molt?

Draw a series of diagrams to illustrate the stages in the metamorphosis of a grasshopper. Label.

Name some other insects that have this type of metamorphosis.

(2) Examine a Riker mount of the metamorphosis of a butterfly. Draw a series of diagrams to illustrate the metamorphosis of a butterfly. Label.

Name some other insects that have this type of metamorphosis.

L 88. REPRODUCTION: FROG

Review the reproductive system of the frog as observed in dissection L. 54.

Describe how fertilization takes place in the frog.

How much parental care do the young frogs receive?

Observe the life history of the frog either in the aquarium or in a preserved life history display.

Make a series of drawings to illustrate the life history of the frog. Describe the changes that take place during the metamorphosis. Make clear why frogs are called amphibians.

L 89. CLEAVAGE IN THE EMBRYO

Examine a prepared stained slide showing early development of the starfish embryo, under low power. Locate the following stages of development:

(1) A zygote, or fertilized egg. A single cell.

(2) Two cell stage. Compare size of the cells with that of the zygote before cleavage.

(3) Four cell stage. Compare the plane of division that formed the four cells with the preceding one.

(4) Blastula. The cavity in the center of the embryo makes it look like a hollow ball.

(5) Gastrula. Find the invagination of certain cells into the cavity. Identify ectoderm, endoderm and mesoderm.

Draw and label each stage observed.

What is an embryo? ____________________

What is meant by cleavage? ____________________

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What is meant by differentiation of the embryo? At what stage does differentiation begin?

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Name tissues which originate from each "germ layer" in vertebrates.

Ectoderm ____________________

Endoderm ____________________

Mesoderm ____________________

APPENDIX

EQUIPMENT AND SUPPLIES

(The following equipment and supplies required for work outlined in this book are best obtained from a reliable biological supply house, such as

Northwest Biological Enterprises,
955 Richmond Avenue,
Victoria, B.C.

General Biological Supply House,
761 East 69th Place,
Chicago, Illinois.)

Standard student compound microscope, minimum one for four students.
Microscope slides
Cover slips
Hand lens, minimum one for two students
Scalpel, one per student
Forceps, one per student
Scissors, one per student
Dissecting tray, one per student
Dissecting needles, two per student
Beakers
Wide mouthed bottles
Pipettes (eye-droppers)
Thistle tubes
Flasks
Battery jars
Glass tubing, 6 mm. outside diameter
Test tubes
Burners
Support, Ring Stand
Rings, for Support
Clamps, for Support
Wire Gauze, with asbestos center
Clamps, tubing
One-holed Rubber Stoppers, assorted
Two-holed Rubber Stoppers, assorted
Flower Pots
Petri Dishes, minimum ten

Display Mounts:
  Grasshopper, Life History
  Monarch Butterfly, Life History
  Frog, Developmental Stages
  Moss, Life History
  Fern, Life History

Prepared Microscope Slides, one of each per microscope:
  Onion Root-tip, l.s.
  Root Hairs, x.s.
  Alfalfa Leaf, x.s.
  Corn Stem, x.s.
  Alfalfa Stem, x.s.
  Basswood (Tilia) Stem, x.s.
  Rhizopus (Black Bread Mold), zygopspore formation
  Bacteria, three types
  Puccinia Graminis (Wheat Stem Rust), stages
  Pleurococcus, w.m.
  Diatoms, w.m.
  Spirogyra, w.m., conjugating
  Spirogyra, w.m. vegetative

- Blood, frog
- Bone, x.s.
- Muscle, Human, three types
- Hydra, x.s.
- Hydra, w.m., budding
- Paramecium, w.m.
- Ameba, w.m.
- Asterias (Starfish) cleavage
- Whitefish or Ascaris mitosis
- Lily, x.s., flower bud or ovary
- Pine, l s. female cone
- Pine, l.s., male cone

Preserved Material:

- Frog, one per student
- Earthworm, one per student
- Grasshopper, one per student

Chemicals: Small quantities of

- Iodine solution
- Methylene Blue stain
- Carmine, dry
- Ammonium hydroxide
- Carbon tetrachloride
- Potassium permanganate crystals
- Molasses
- Corn starch
- Fehling's solution
- Calcium nitrate, c.p.
- Potassium chloride, c.p.
- Potassium phosphate, K_3PO_4 c.p.
- Potassium nitrate, c.p.
- Sodium phosphate, Na_3PO_4 c.p.
- Calcium chloride, c.p.
- Magnesium sulfate, c.p.
- Ferrous sulfate, c.p.
- Glucose
- Nitric acid
- Hydrochloric acid
- Ether
- Lime for limewater
- Pepsin, powder
- Pancreatin
- Bile salts
- Peptone, Bacto
- Beef extract

Seeds:

- Radish
- Wheat
- Oats
- Barley
- Bean
- Pea
- Corn

Plants:

- Geranium
- Coleus

Cellophane, non-waterproof
Lens paper
Dry yeast
Filter paper

Date Due

Date Due

DUE JAN 27 '78

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